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UPGRADED FAA AIRFIELD CAPACITY MODEL. VOLUME I. SUPPLEMENTAL USER'S GUIDE,

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16. Abstract

The FAA Airfield Capacity Model, a computer program designed to quickly calculate the runway capacity of an airport, has recently been upgraded.

Several new features have been implemented in the upgraded version. Among these are improved input and output formats for easier usage, the capability to compute runway capacity for up to eleven different percentages of arrivals in a single run (as opposed to a separate run for each percentage), and provisions for calculating the capacity of alternating arrivals to a pair of parallel runways. Several other runway configurations have been added to the model, or improved, as well.

Other changes have been made to the internal logic of the model which will result in reduced running times and/or improved accuracy. The resulting capacities may, therefore, differ from the results obtained with the previous version. In most cases this will not affect the ranking of the potential airfield changes under evaluation.

This report documents the upgraded FAA Airfield Capacity Model. Volume I, "Supplemental User's Guide," provides a general overview of the major changes that have been made to the program and includes revised versions of the relevant chapters in the existing User's Manual, FAA-RD-76-128, "Model Users' Manual for Airfield Capacity and Delay Models." Volume I may also be used by itself as a guide to the input and output requirements of the upgraded model.

Volume II is a detailed technical description of the revisions to the program, including flow charts of the logic and evaluations of various alternative logics.

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Concluded)

LIST OF ILLUSTRATIONS

1. INTRODUCTION

1.1 Description of the Model

The FAA Airfield Capacity Model is a computer program which analytically calculates the maximum operational capacity of a runway system under a wide range of conditions. The user has considerable freedom to vary the characteristics of the runway, aircraft, and ATC system.

The capacity model was originally developed in the early 1970s by a consortium which included Peat, Marwick, Mitchell and Company (PMM&Co.) and McDonnell Douglas Automation (MCAUTO). The program was further modified by the Systems Research and Development Service (SRDS) branch of the FAA. The model has been used by the FAA for the Airport Capacity and Delay Task Force studies, and is currently available to the public through the Control Data Corporation (CDC) timesharing computer service. It is this SRDS version which will be referred to in this report as the "original" version of the program, since it was the basis for the upgraded version described herein.

A major effort to upgrade the capacity model has been concluded. Modifications to the program focused on three principal areas:

- adding new functions and abilities
- updating to incorporate the latest ATC procedures
- correcting minor program errors.

1.2 Description of the Documentation

This report constitutes Volume I of a two-volume set of documentation on the upgraded capacity model. Volume I, the Supplemental User's Guide, includes a brief, non-technical description of the principal changes to the program (Section 2) and a summary of changes to the model input and output (Section 3). In addition, two appendices contain revised versions of the chapters in the original User's Manual (FAA-RD-76-128, Reference 1) which pertain to the Airfield Capacity Model.

Volume II of the documentation is a technical description of the modifications which have been made to the Airfield Capacity Model. This report describes, in detail, the original model logic and the process by which the improvements to the model were developed, tested, evaluated and implemented.

Comparisons are presented for the capacity results and running costs of the original and the upgraded versions of the Capacity Model.

Several topics which should be contained in the full documentation of the Airfield Capacity Model will not be fully discussed in the present report. These include:

- o a separate list of all the assumptions in the model
- o default values for all parameters
- o sources of input data
- o discussion of techniques for effective use of the model.

It is hoped that these and other such areas will be included in any future revision of the User's Manual.

2. MODEL CHANGES AFFECTING THE USER

This section briefly describes the more significant model modifications and the way in which they affect the user. Many of these features are optional capabilities that the user should be aware of, to use if he so wishes. Appendices A and B will give more details on how to implement these options.

The model changes are divided into two categories: those which affect all runway configurations, and those which affect only particular configurations.

2.1 General Changes

2.1.1 Multiple Arrival Percentages

The FAA Airfield Capacity Model calculates capacity at a given arrival percentage by first calculating an arrival-priority capacity (maximum number of arrivals plus whatever departures are possible) and a departure-priority capacity (similarly, the maximum number of departures). It then interpolates between these points, or drops the excess arrivals or departures, to reach the desired arrival percentage.

In the original version, only one arrival percentage could be specified per run. If the capacities at several arrival percentages were desired, several runs would have to be made; the same arrival-priority and departure-priority capacity values would be calculated each time, but the details of the interpolation would differ. Calculating these capacity values is much more expensive than interpolating between them. In the upgraded version, up to 11 different arrival percentages can be specified during a single run (on the OTHERS line, line 20 of the input file -- see Appendix A), saving the expense of recalculating the arrival-priority and departure-priority capacities.

In the original version, an arrival percentage of "9999" would result in the output of the arrival-priority capacity values. The upgraded version will, in addition, output the departure-priority capacity values if the arrival percentage is "8888."

2.1.2 Gap Stretching

When the arrival priority capacity is calculated, the maximum number of arrivals are generated first, and departures are fitted into the resulting gaps as feasible. It would seem likely that certain gaps could be "almost large enough" to fit an additional departure into, and that additional departure capacity could thus be gained by "stretching" these gaps slightly.

There is a great deal of difficulty, however, in determining which gaps to stretch and by how much to stretch them, primarily because we are dealing with a probable number of departures per gap, rather than a deterministic number. (In other words, stretching a specific gap between two individual arrivals may increase the number of departures in that gap from 1 to 2, but stretching all the gaps between those two arrival types might only increase the average number of departures per gap from 1.8 to 1.9.) The revised program operates by stretching all gaps, at least initially, by a pre-specified increment, but retaining the stretch only when there is a capacity benefit.

Capacity is first calculated for the (unstretched) arrival-priority case. Next, each gap is stretched by the increment "x." The expected number of departures in each gap is then calculated. If there is no benefit to the gap stretch, the gap is returned to its unstretched size. Arrival and departure capacities are then recalculated, given the remaining stretched gaps. The resulting capacity is referred to as the first intermediate point on the capacity curve.

For the second intermediate point, each gap is stretched by twice the increment, relative to its unstretched size, and the testing is repeated.

The user can specify both the maximum number of intermediate points and the gap-stretching increment in the INCIAT line, line 26. If these values are not specified, the program defaults to one intermediate point with a maximum gap stretch of 20 seconds. If an arrival percentage of "7777" is specified, the capacity at each intermediate point will be output.

2.1.3 Deletion of the Equal-Priority Models

The original version of the Capacity Model had an option available for calculating capacity at 50% arrivals. Arrivals and departures were given equal priority in runway use and strict alternation of arrivals and departures was enforced. This meant that some arrival gaps would be stretched to accommodate a single departure, while another gap which was large enough for two or more departures without stretching might have unused capacity. This type of inefficiency resulted, in some cases, in an "equal-priority" capacity which was less than that obtained by running arrival-priority for part of the hour and departure-priority for the remainder (i.e., interpolation between the two values).

The equal-priority logic has been removed from the upgraded Capacity Model. It was felt that the gap stretching procedure described in the previous section provides a better means of calculating capacity at 50% arrivals. Strict alternation of arrivals and departures is no longer enforced, but the overall balance between arrivals and departures is preserved.

2.1.4 First Enqueued Departure Mix

In computing the capacity of a mixed-mode (arrivals and departures) runway, the departure capacity is based upon the most limiting aircraft type. In this way the specified fleet mix is preserved.

The original program logic assumes that the probability that a particular aircraft type is the first departure in an arrival gap is the same as that type's proportion of the overall aircraft mix. In reality, this probability is also affected by the difficulty with which each departure type can be inserted into the previous gap. In other words, if a departure does not fit into the current gap, it will be first in line to depart in the next gap. The original program logic, on the other hand, would in effect make that aircraft go back to the end of the departure queue.

The "first enqueued departure" (f.e.d.) mix logic that has been added to the program recognizes explicitly that aircraft do not show up at random to be first in line to depart. The f.e.d. mix is calculated iteratively, since changing the mix for the first departure changes the probability of getting out the second and third departures, which in turn affects the mix for the first departure in the next gap. However, the f.e.d. mix converges rapidly. The user can specify both the maximum number of iterations and the convergence criterion to be applied (INCIAT, line 26).

2.1.5 Separate Probability of Violation for Interarrival Times

Several steps in the model logic call for the calculation of a buffer time which is then added to a nominal event time. For example, a 5% buffer is added to average runway occupancy time to derive a "protected occupancy time" which is used for planning purposes. This 5% probability of violation (PV) may be interpreted as meaning that only 5% of all occupancy times will be greater than the "protected time."

A buffer is also added to minimum interarrival time (the time between arrivals at the threshold based on minimum separations) to derive an average interarrival time. For the present day ATC system, this is also a 5% buffer, which in this case means that only 5% of all interarrival times would be below the minimum interarrival time. In the future, however, metering and spacing will be automated, and a 1% buffer will be used. A lower probability of violation is required because it is desirable to limit the number of times a human controller must step in to resolve the violations.

The original program used just a single PV, and therefore could not handle the case of a 5% buffer on runway occupancy and a 1% buffer on interarrival time. Two PVs can be specified in the upgraded program, one for interarrival time and one for all other applications. These are input on the revised OTHERS line, line 20.

2.2 Configuration - Specific Changes

The following model modifications apply only to certain runway configurations.

2.2.1 Single Runway - Optional Use of "Q-Logic"

ATC procedures require that certain separations be applied between consecutive departures, for conflict- and vortex-avoidance. These separations must be applied even if there is an intervening arrival.

It is a simple matter to consider the effect of these departure-departure separations within a given arrival gap, but considerably more difficult to account for their effect between gaps. This is because we now must consider the aircraft type of the last departure in the previous gap and its position within that gap, which in turn depends upon the size of that gap and the other departures within that gap. The logic used in the model for considering the effect between gaps deals with probabilities for the aircraft type, the position within the previous gap, and the effect on departures in the current gap. We refer to this as the "Q-logic," since Q is a unique variable used therein.

In the original model version, the Q-logic is used only for the close parallel (dual-lane) and intersecting runway cases. It was not felt to be needed for the single runway, because the normal separation between departures in different gaps is usually greater than the separation requirement (the first departure must clear the runway before the arrival lands, and then the arrival must clear before the next departure can be released -- with buffers, the time between departures would be about 100 seconds). However, since 120 seconds is required for a non-heavy departure behind a heavy departure, it is possible for the previous departure to affect the departures in the current gap.

It has therefore been left up to the user to decide whether or not to use the Q-logic with a single runway. An arbitrary negative value for DIAGSP, on the ALTARR line (line 25), is used to implement the single-runway Q-logic. In most cases, the effect will be quite small.

2.2.2 Parallel Runways - Alternating Arrivals

The latest version of the ATC procedures (Handbook 7110.65B, Reference 2) allows the operation of dependent arrivals to parallel runways with a 2.0 nmi separation applied diagonally between consecutive arrivals. The normal longitudinal separations still apply between consecutive arrivals to the same runway. A subroutine has been added to the program to calculate capacity with alternating arrivals.

It is necessary to consider a set of four alternating arrivals to determine the spacing between two arrivals to the same runway. For example, aircraft A is a heavy aircraft ($>$ 300,000 lbs.) landing on runway 1 (Figure 2-1). Aircraft B, a "small" bound for runway 2, is 2.0 nmi diagonally behind A. C, a "large" aircraft, is 5.0 nmi behind A on runway 1 because of intrail vortex requirements. The next arrival to runway 2 would be 2.0 nmi diagonally behind C, and therefore 5.0 nmi behind B, a small aircraft which would normally require only a 3.0 nmi separation or less. When the spacing between B and D is determined by the separation between A and C, we refer to this as "shadow spacing."

"Shadow spacing" can also result from speed differentials between aircraft or other constraints. The new subroutine deals with "shadow spacing" by selecting a set of four aircraft, and then calculating the earliest time for each aircraft to cross the threshold, subject to the constraints of

- separation from previous arrival, same runway
- separation from previous arrival, other runway
- time to fly from gate to threshold
- runway occupancy time, previous arrival.

The subroutine also accounts for runway thresholds or approach gates which are displaced relative to each other.

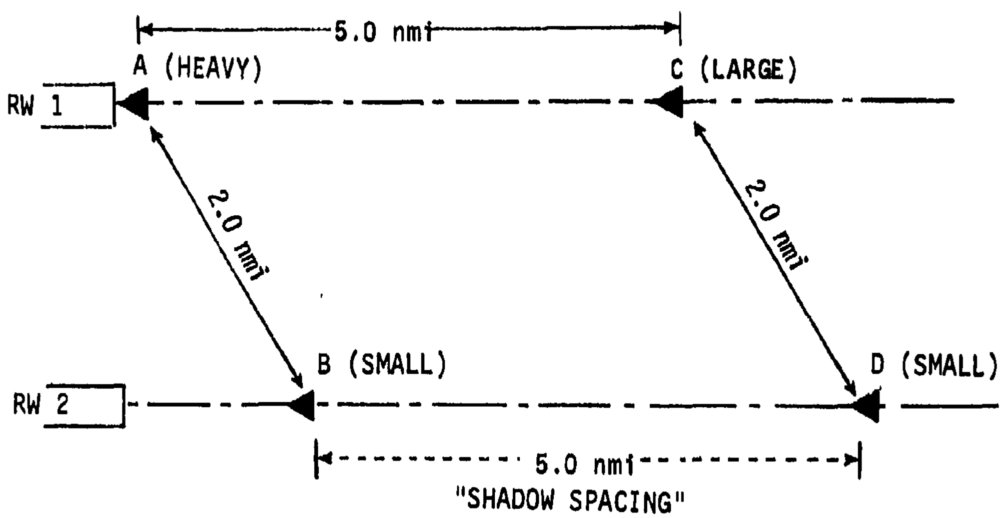


FIGURE 2-1
ILLUSTRATION OF "SHADOW SPACING"

2.2.3 Intersecting Runways - New Configurations Added

Only two configurations of two intersecting runways were available in the original program -- arrivals on one, departures on the other, and mixed on one, departures on the other. The latter configuration implies that departures can be run on both runways, but such a configuration was not available by itself.

The revised program now includes such an option (configuration 6-1, runway diagram number 52). Operationally, this configuration is similar to alternating arrivals -- the interval between departures depends not only on the required separation between aircraft on the same runway, but also on the separation needed at the intersection behind an aircraft on the other runway, due to wake vortices. Consequently, a similar logic is used. A set of four departure aircraft is selected, and the earliest release time is generated for each, based on the relevant constraints.

If more capacity can be achieved by operating departures on just a single runway, this single-runway capacity will be returned by the program, along with the message, "ALL DEPARTURES ARE ON SINGLE RUNWAY."

2.2.4 Complex Configurations

"Complex configurations" are, in general, those with more than two runways. They are treated in the program as combinations or special cases of the simple configurations -- single runway, two parallel, or two intersecting runways.

Two aspects of this handling of complex configurations were open to question: the simplification of complex configurations in full IFR conditions (formerly called PVC), and the calculation of the departure-priority capacity of complex configurations. Full IFR conditions, with full applications of IFR rules, were rarely considered; for example, departures and arrivals on separate close-spaced parallel runways were considered to be independent, contrary to IFR rules.

Details of the revised treatment of complex configurations are presented in Appendix D of Volume II.

3. CHANGES TO INPUT/OUTPUT

In addition to the changes to the program logic itself, numerous revisions were made to the program input and output. Some of the revisions were necessitated by the changes to the program logic: input data required for the new program functions, for example. Other input changes resulted from the deletion of certain program functions which are no longer used. Program output was revised to make it more readily usable.

Input data to the program may be provided in either of two ways: interactively or in input file form. In the interactive mode, the program asks specific questions about the case to be run (aircraft mix, runway configuration, etc.) and uses the results to construct an input file containing all necessary data for a single run. The resulting input file may be saved for future runs.

In the input file (batch) mode, input data is contained in a separate data file or, perhaps, a deck of cards (depending on the manner in which the program is implemented). This data file may have been created directly by terminal entry; interactively, as described above; or incrementally, by modifying a pre-existing input file. Regardless of the procedure used, the batch mode presents several advantages, including fuller control over the input values and the ability to model several different cases with a single run.

In the following sections, the principal changes to program input and output will be briefly described. More complete descriptions will be found in Appendices A and B, the substitute chapters for the User's Manual. The general form of the input and output have been maintained, but a sufficient number of details have been changed that input files for the original program version will not work for the upgraded version.

3.1 Interactive Input

The interactive capability of the FAA Airfield Capacity Model permits any user to calculate capacities without requiring a detailed knowledge of the program. The program asks the user a series of questions about the runway configuration, ATC system, and aircraft fleet, and uses the answers to construct an input file for the capacity program. For subsequent runs, the input file can be saved and edited, or else the program can be rerun interactively.

Appendix B of this report will present each question asked by the program (in both long and short form), and will discuss the nature and format of the answers expected from the user. All these questions would not appear in any single run, because certain questions are dependent upon the answers to previous questions. To give two examples, some questions will be asked only if a parallel runway configuration has been specified, others only if an intersecting configuration is to be analyzed.

The following are some of the principal changes which were made to the interactive mode of the program.

3.1.1 Standard ATC Scenarios

The number of standard ATC scenarios has been reduced to four: present, near-term, intermediate-term, and far-term. These scenarios are described in Table 3-1, which shows the explanatory message printed out by the Capacity Model in the interactive mode. Each "scenario" represents a pre-stored file of arrival-arrival and departure-departure separations, metering and spacing parameters, and maximum runway occupancy times (for future scenarios). These values have been obtained from FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay" (Reference 3).

3.1.2 Weather Conditions

The weather conditions recognized by the program have been renamed to reduce some confusion. They are now

- VMC -- Visual Meteorological Conditions
- MMC -- Marginal Meteorological Conditions
- IMC -- Instrument Meteorological Conditions.

These conditions are explained in Table 3-2.

3.1.3 Alternating Approaches

As described in Section 2.2.2, the program can now calculate the capacity for alternating parallel arrivals with a specified diagonal separation. The interactive mode has been modified to request the necessary data for the calculation. If a parallel runway configuration has been specified and the distance between runways is more than 3000 feet, the program will ask "RUN ALTERNATING APPROACHES?" If the answer is YES, the next question will request the diagonal separation standard to apply and the amount of threshold stagger, if any.

TABLE 3-1

EXPLANATION OF ATC SYSTEM CODES

THE FOLLOWING ATC SCENARIOS REPRESENT FAA E & D PLANNING AS OF JANUARY, 1980, AS DESCRIBED IN FAA-EM-78-8A.

ATC CODE	TIME FRAME	DESCRIPTION
P	PRESENT	CURRENT ATC SYSTEM
N	NEAR-TERM	VAS, TERMINAL FLOW MANAGEMENT
I	INTERMEDIATE	WVAS, TERMINAL FLOW MANAGEMENT, REDUCED RUNWAY OCCUPANCY IN IMC
F	FAR-TERM	WVAS, ADVANCED TERMINAL FLOW MANAGEMENT FURTHER REDUCTIONS IN IMC RUNWAY OCCUPANCY

TABLE 3-2

EXPLANATION OF WEATHER CONDITIONS

WEATHER		VISIBILITY* (STAT. MI.)	CEILING* (FEET)	OPERATIONAL IMPACT
VMC	VISUAL METEOROLOGICAL CONDITIONS	5.0	5000	VISUAL APPROACHES -- PARALLEL RUNWAYS >700' APART ARE INDEPENDENT
MMC	MARGINAL METEOROLOGICAL CONDITIONS	2.5	900	IFR SEPARATIONS APPLY BETWEEN ARRIVALS -- PARALLEL RUNWAYS <4300' APART HAVE DEPENDENT ARRIVAL OPERATIONS -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS >700' APART ARE INDEPENDENT BECAUSE VISUAL SEPARATIONS ARE APPLIED
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS	0.0	0	ALL IFR PROCEDURES ARE IN EFFECT -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS <2500' APART ARE DEPENDENT

*THESE ARE VALUES WHICH ARE INPUT TO THE PROGRAM, NOT BREAKPOINTS BETWEEN WEATHER CONDITIONS

3.1.4 Intersection Clearance Times

For intersecting runway configurations, the program asks for the distance from threshold to intersection for each runway. This is used to compute the time required for arrivals and departures to clear the intersection. Formerly a table look-up process, this calculation is now performed explicitly on the basis of

- o constant acceleration for departures of 6 ft/s^2
- o liftoff at 1.4 times the stall speed
- o arrivals touch down 1500 ft from the threshold, then decelerate at 5.3 ft/s^2 to a runway taxiing speed of 60 kn.

These intersection clearance times are then used to compute the arrival/departure and departure/arrival separation requirements. If the aircraft are airborne at the intersection, this separation must account for the required vortex separation between aircraft at the intersection. For intersecting runway configurations, the interactive program asks specifically, "ARE AIRCRAFT AIRBORNE AT INTERSECTION?"

3.1.5 Arrival Percentages

As stated in Section 2.1.1, the program will now accept up to 11 values of arrival percentages in a single run. This is sufficient to allow the user to specify 0% to 100% by 10% increments.

The value to be input could also be one of three special values:

- o 9999 -- the program prints the arrival-priority capacity values, regardless of the arrival percentage.
- o 8888 -- the program prints the arrival-priority and departure-priority capacity values.
- o 7777 -- the program prints these two sets of values plus as many intermediate points as have been specified. The program defaults to one intermediate point with a "stretch" of 20s.

These special values are valid only in the first position; elsewhere they are ignored. This is because they are not needed in other positions -- normal output mode includes printout of the arrival-priority capacity values, plus the departure-priority values and whatever intermediate points were necessary to determine the capacity at the desired arrival percentage.

3.1.6 Average Runway Occupancy Times

The interactive program previously requested the location and types of exits along the runway and used this information to compute the average runway occupancy times (using stored values). The upgraded program asks for these average times directly.

3.2 Batch Input

The capacity program obtains the information it needs on aircraft fleet mix, approach speeds, etc. from a fixed format input file.

Appendix A of this report will describe each line of the input file as it has been restructured for the upgraded Capacity Model. Some of the input lines have not changed, in either form or content, from what was required by the original version of the capacity program.

3.2.1 Line 0, NEWRUN

The third value on this line previously served as an indicator of whether or not to run the equal-priority model. Since the equal-priority models have been discontinued, this indicator is now used to signal the model to run alternating arrivals.

3.2.2 Line 2, ARBAR2

Input on this line now consists of 4 average runway occupancy times, one for each aircraft class, on a single line. Previously one line was used for each aircraft type; each line contained up to 11 values of runway occupancy, one for each runway exit. These values were then combined with the information on line 3, EXITPT (the percentage of use of each exit) to determine the overall average occupancy time, which is now input directly. Line 3, EXITPT, is no longer used.

3.2.3 Line 11, TWOIN

This line provides data used by some intersecting runway configurations. Two new input items on this line are:

- a flag which indicates whether or not aircraft are airborne at the intersection

- the average time for a departure to clear the intersection.

3.2.4 Lines 14 to 18

These lines are no longer used. They were originally associated with the gate and taxiway capacity models, which have been dropped from the program.

3.2.5 Line 19, SIGMAS, and Line 20, OTHERS

Line 19, SIGMAS, contains all the standard deviations used in the program. This data has been moved from line 20, OTHERS, in order to make room on that line for up to 11 different values of arrival percentage. The three special values of arrival percentage were discussed in Section 3.1.5.

3.2.6 Line 25, ALTARR

Information needed to run alternating arrivals with a diagonal separation standard has been grouped on this line. It includes

- the diagonal separation standard
- the separation between runway centerlines
- the relative runway threshold displacement
- the relative approach gate displacement.

3.2.7 Line 26, INCIAT

This line has been added to the input file to provide required information for the first-enqueued-departure logic (Section 2.1.4) and for the gap stretching logic (Section 2.1.2). This data includes:

- the maximum number of iterations for the f.e.d. mix
- the convergence criterion for the f.e.d. iterations
- the maximum number of points for which arrival capacity is calculated (arrival-priority point plus the number of intermediate points)
- the increment by which interarrival times are stretched.

3.3 Changes to the Output

Output format has been changed slightly, and some additional information is now printed out, in an attempt to make the output more useful. Figure 3-1 illustrates some of these changes with the output from a typical run.

Standard output now includes:

- o a description of the configuration being run
- o each capacity value (arrival-priority, departure-priority, and any intermediate points) used to calculate the capacity at the desired arrival percentage
- o for each intermediate point, the maximum value by which each gap might have been stretched (actual stretch for any gap might have been less, if the maximum stretch was not beneficial)
- o details of the procedure for achieving the desired arrival percentage (drop excess arrivals or departures, or operate part of the hour in one mode and the remainder in another).

For certain configurations, additional informational messages are printed. For example, for alternating arrivals with diagonal separation, the message "ALTERNATING APPROACHES --- x NMI DIAGONAL / y FT" will appear, where x is the diagonal separation and y is the separation between centerlines. If an intrail separation is used instead, the message is "ALTERNATING APPROACHES --- x NMI INTRAIL SEPARATION."

In other cases, the program evaluates capacity under two different operating strategies for the same configuration and chooses the strategy which maximizes capacity. A message will then be printed which identifies the preferable strategy. For example, two intersecting runways with departures on both may be run as two runways or with all departures on a single runway. In the latter case, the program outputs the message "-- ALL DEPARTURES ARE ON SINGLE RUNWAY."

Program output is also discussed in the appendices.

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0
   6   2   0
RUNWAY 1 1 0
0.0 0.0 0.600.40
RUNWAY 2 1 0
0.0 0.0 0.600.40
ARBAR2 1 2 0
 34. 34. 42. 45.
DLTAIJ 0 4 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.5 2.5 2.0 2.0 3.0 3.0 2.5 2.0
APPSPD 0 5 0
  95 120 130 140
DRBAR  0 6 0
  29  34  39  39
TD     0 7 0
  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60
GAMA   0 8 0
   6   6   6   6
TGRBAR 0 9 0
 23. 22. 27. 27.
ADSR   112 0
  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.
DICBR  013 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0
SIGMAS 019 0
  4.  8.  0.  0.  6.
OTHERS 020 0
0.050.01 2.0 0.0   0 3.00.0    50
INCIAT 026 1
   1.050   2 20.

TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   90.10  ARRIVALS =  45.81     DEPARTURES =  44.30

    DEPARTURE PRIORITY CAPACITY
              TOTAL =   60.00  ARRIVALS =   0.0      DEPARTURES =  60.00

    CAPACITY AT POINT #  2                MAX GAP STRETCH =  20. SEC
              TOTAL =   89.38  ARRIVALS =  43.17     DEPARTURES =  46.21

TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
          AT POINT   1 FOR  66 PERCENT OF THE HOUR, AND
          AT POINT   2 FOR  34 PERCENT

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    89.9  ARRIVALS =   44.9  DEPARTURES =   44.9

          *****     *****     *****     *****     *****     *****
```

FIGURE 3-1
EXAMPLE OF PROGRAM OUTPUT

APPENDIX A

REVISED VERSION OF CHAPTER 2, "RUNWAY CAPACITY BATCH MODEL"

The following pages are intended to replace Chapter 2 of Reference 1, "Model Users' Manual for Airfield Capacity and Delay Models." It incorporates changes from the upgraded version of the FAA Airfield Capacity Model. Additional technical details may be found in Volume II of this report.

Any references made in this Appendix to tables, figures, etc., pertain to the contents of the Users' Manual, either original or revised, and are not to be confused with previous sections of this report. Two page numbers will be found on each page; the uppermost (17-62f) refers to the numbering of the original report, while the lower number (A-3 through A-57) refers to the current report.

A Table of Contents for the revised Chapter 2 is presented on the following pages as a guide for the user. The page numbers given refer to the numbering scheme of the original report.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 2 -- RUNWAY CAPACITY, BATCH MODEL

2.1 Introduction

2.1.1 Overview

The FAA Airport Capacity Model is a computer program which analytically calculates the maximum throughput of a runway system. In the program, "capacity" is defined as the maximum sustainable runway throughput, on a long-term basis, of arrivals and departures given a continuous sustained demand. Although actual throughput may be different, due to short-run variations in aircraft mix, control procedures, etc., this theoretical capacity is valid for comparisons between airports or between developmental alternatives.

Capacity is computed by determining the minimum time between successive arrivals and inverting this time to find the maximum number of arrivals per hour. The maximum number of departures which can be inserted between the arrivals is then calculated, to give the "arrival-priority" capacity. If a specific ratio of arrivals to departures is specified, the departure-priority capacity is calculated. The desired capacity may be obtained by dropping excess arrivals or departures, or by interpolating between the arrival-priority and departure-priority points.

Details of the capacity calculations are described in the next Section. The technique for achieving the desired arrival-departure ratio is described in Section 2.3, along with other information about the general program workings.

The input items required for the calculations will be described in Section 2.4 along with the required data formats. Section 2.5 will discuss output. Some details of the program software and operating procedures will be given in Section 2.6. Section 2.7 contains reference tables describing the breakdown of complex runway configurations into simpler components. Lastly, several examples will be presented and discussed in Section 2.8.

2.1.2 Definition of Terms

In the following discussion, the term "runway configuration" will mean a unique runway layout, with a specified number and arrangement of runways, and with the arrivals and departures assigned to particular runways. A "model" is the subsection of the program logic, representing a general runway geometry which is unique for each configuration. Thirteen major geometries, or models, are represented in the program:

Model No.	Geometry
1	Single Runway
2	Two Parallel Runways
6	Two Intersecting Runways
3	Three Parallel Runways
4	Four Parallel Runways
5	Two Open V Runways
7	Three Intersecting Runways
10	Three Open V Runways
11	Four Open V Runways
12	Two Runways Intersecting Beyond Threshold
13	Three Runways Intersecting Beyond Threshold
14	Four Runways Intersecting Beyond Threshold
15	Four Intersecting Runways

Typical layouts of these geometries are depicted in Figure 2-1.

For each model, the operating strategy must also be specified. The "operating strategy" defines whether a runway is used for arrivals, departures, or mixed operations. It can also provide some information on the spacing between parallel runways and whether operations on non-parallel runways are converging or diverging. For example, model 2 (two parallel runways), strategy 20 represents a close-spaced pair (700-2499 ft apart), with arrivals on runway 1 and departures on runway 2. This configuration can also be referred to in a shorthand form as 2-20(C:A,D).

The strategy codes are unique for each model. A complete listing and explanation of each model and strategy combination appears later in this chapter, in Section 2.7.

2.2 Capacity Calculation Logic

The development of the Airfield Capacity Model logic equations is contained in References A and C. This section presents a summary of the Airfield Capacity Model logic.

2.2.1 Arrival Operations On a Single Runway, Model 1-1(A)

The capacity of an arrival-only runway is given by:

$$\text{CAPACITY} = \frac{3600}{\text{average time separation between arrivals}} = \frac{3600}{\text{TAA}}$$

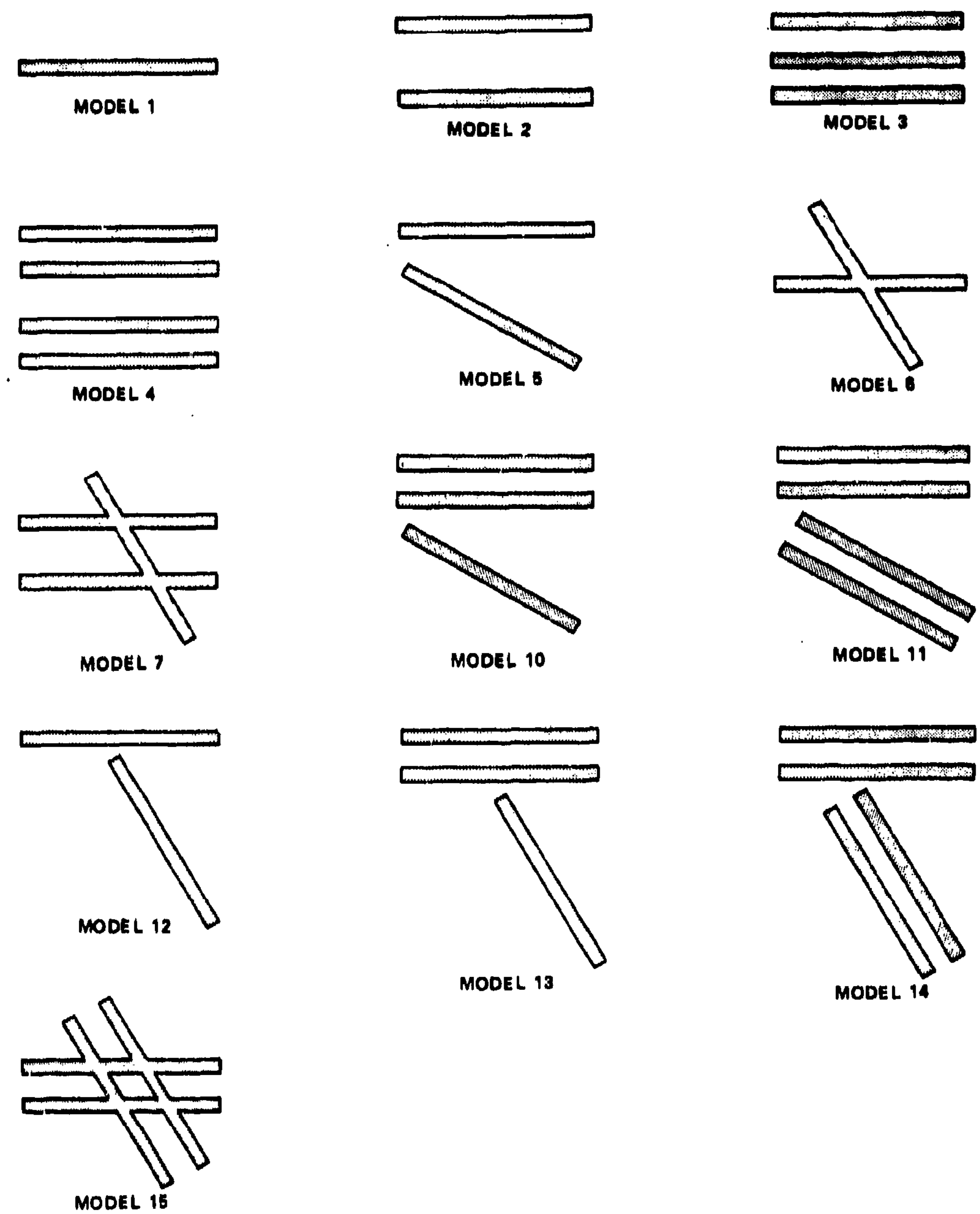


FIGURE 2-1
RUNWAY USE CONFIGURATION GEOMETRIES

Model 1-1(A) determines the required time separation for each aircraft class pair ($\overline{TAA}(i,j)$) by comparing the arrival runway occupancy time of the lead aircraft i and the time separation over threshold for the aircraft pair ij. The larger of these two values is assumed to be the required time separation over threshold for this pair of arrival aircraft classes. The frequency with which each aircraft class pair would occur is assumed to be the product of the mixes of the aircraft classes involved: e.g., the frequency of occurrence of aircraft class pair ij = %i X %j / 1000. Therefore, the average time separation between arrival pairs is computed as the sum over all class pairs of the product of $\overline{TAA}(i,j)$ for each aircraft class pair and the frequency with which the aircraft class pair is expected to occur:

$$TAA = \sum_{i,j} \overline{TAA}(i,j) * \%i * \%j \;/\; 1000$$

In determining arrival runway occupancy time and the time between arrivals the Airfield Capacity Model considers the variability of aircraft, pilots and controllers as expressed by the standard deviations of arrival runway occupancy time and arrival-arrival separation. In addition, in determining the time between arrivals over the threshold, the Airfield Capacity Model considers the approach velocities of the aircraft pair and the length of the common final approach path. If the velocity of the trailing aircraft is operating at a lower velocity than the lead aircraft, the specified minimum arrival-arrival separation is assured at the merge point of the two approach paths.

?.2.2 Departure Operations On a Single Runway, Model 1-2(D)

The capacity of a departure-only runway is given by:

$$\text{CAPACITY} = \frac{3600}{\begin{array}{l}\text{average time separation}\\ \text{between departures}\end{array}} = \frac{3600}{TDD}$$

Model 1-2 determines the required time separation for each aircraft class pair ($\overline{TDD}(k,l)$) by comparing the departure runway occupancy time of the lead aircraft k and the time separation between departures (from threshold) for the aircraft pair kl. The larger of these two values is assumed to be the required time separation at threshold for this pair of departure aircraft classes. The average time separation between departures is computed as the sum over all class pairs of the product of $\overline{TDD}(k,l)$) for each aircraft class pair and the frequency with which the aircraft class pair is expected to occur.

$$TDD = \sum_{k,l} \overline{TDD}(k,l) * \%k * \%l / 1000$$

2.2.3 Mixed Operations On a Single Runway, Model 1-3(B)

The capacity (without regard to arrival percentage) of a single runway used by arrivals and departures is given by:

CAPACITY = (Arrival only runway capacity) + (Number of departures that can be inserted between arrivals)

To insert departures between arrival pairs, Model 1-3(B) imposes the following requirements:

- o departures cannot roll if an arrival is on the runway
- o departures cannot roll if:
  - (1) an arrival is within some specified distance of the runway threshold, or
  - (2) the departure cannot clear the runway before the arrival comes over the threshold
- o departure-departure separations must be met to insert multiple departures between an arrival pair.

Employing these conditions, Model 1-3 computes the probability of inserting 1, 2 or 3 departures between each arrival pair. The interleaved departure capacity is then determined from these probabilities and the aircraft mix.

2.2.4 Simultaneous Arrival Operations on Close Spaced Parallel Runways in VMC, Model 2-19(C:A,A) and Model 2-24(C:B,B)

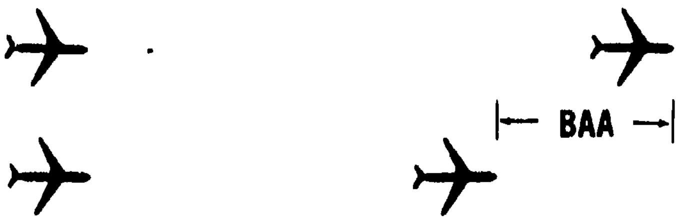
In VFR operating conditions, simultaneous arrival operations can be made to close spaced parallel runways (i.e., runways with centerline separations from 700 to 2499 feet) if neither of the aircraft is a heavy jet. When a heavy jet is present on the final approach path, the runways become dependent and the trailing aircraft on both runways are required to observe the single runway wake turbulence separations (e.g., 4 nmi for heavy-heavy and large-small, 5 nmi for heavy-large and 6 nmi for heavy-small aircraft pairs under current procedures).

To compute this capacity, the program considers the following quadruplet of airplanes:

If neither of the lead aircraft (i or j) is a heavy, the two arrival streams are independent, and the airfield capacity is the sum of the single runway capacities. If one or both lead aircraft is heavy, the program calculates all four possible separations (i-k, i-l, j-k, and j-l), and takes the largest separation to be governing for this quadruplet. An average weighted separation is then obtained for all appropriate quadruplets of aircraft classes. The capacity thus obtained is weighted by the probability that one or both lead aircraft is a heavy, and combined with the weighted capacity of the non-heavy case, to obtain an overall arrival capacity.

If mixed operations occur on either runway, the departure capacities are also calculated for the vortex and non-vortex cases and then combined to given an overall departure capacity.

NOTE: For this runway use configuration, it is possible to specify a buffer time separation (BAA) between the lead aircraft pair as illustrated below:



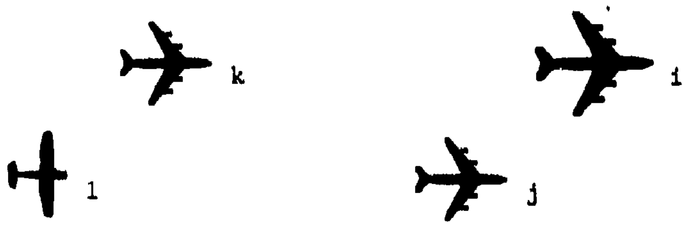
This buffer between simultaneous arrivals is normally used to keep faster wake turbulence producing aircraft from getting ahead of slower aircraft on a parallel approach by the time the aircraft pair reaches the runway thresholds.

2.2.5 Arrival Operations on Intermediate Spaced Parallel Runways in IMC, Model 2-7(M:A,A)

As used in this report, intermediate parallel runways are those with centerline separation between 2500 and 4299 feet. In IFR operating conditions, simultaneous arrival approaches cannot be made on these runways. However, since the runway centerline separation is equal to or greater than 2500 feet, no increased arrival separation is required for cross track wake turbulence; a 3.0 nmi separation can be applied intrail between aircraft on different runways. Full separations, including wake vortex buffers, apply between consecutive arrivals to the same runway.

Recent changes to ATC procedures allow such alternating arrivals to be run using a 2.0 nmi diagonal separation if the runways are separated by 3000 feet or more. The Capacity Model can calculate these capacities as well.

Whether intrail or diagonal separations are used, the program considers a quadruplet of four aircraft, ijkl:



The interval between arrivals i and j is calculated first, based on the intrail or diagonal separation. The arrival time of k is then calculated, as constrained by:

- o the diagonal or intrail separation between j and k,
- o the intrail separation between i and k, and
- o the runway occupancy time of arrival i.

The process is repeated for arrival l. The difference between arrival times for j and l is averaged for all combinations of i, j, k, and l, then inverted to obtain the arrival capacity of each runway.

2.2.6 Dual-lane Runway -- Close Parallels, Arrivals On One and Departures On the Other -- Model 2-20(C:A,D)

In IMC, operations on a close parallel pair of runways are dependent. Departures on one runway cannot be released if an arrival to the other runway is within a certain distance of the threshold (the departure/arrival separation), but can be released as soon as the arrival touches down.

The logic for computing the departure capacity of this configuration is similar to that used for the single runway, Model 1-3(B). After the interarrival times are obtained, the probability of 1, 2, or 3 departures in each interarrival gap is calculated. The runway occupancy time of the arrival is not a constraint, but an additional constraint applies: departure-departure separations are enforced, not just between departures in the same gap, but also between departures in adjacent gaps. This is rarely necessary for mixed operations on a single runway because the need to wait for the arrival to exit the runway is usually limiting.

2.2.7 Two Intersecting Runways With Arrivals On One and Departures On the Other -- Model 6-2(A,D)

The logic for intersecting runways and that for dual-lane runways are similar. The probability of 1, 2, or 3 departures per inter-arrival gap is subject to:

- the time for an arrival to clear the intersection or exit the runway,
- the required departure/arrival separation existing when the departure crosses the intersection,
- required departure/departure separation, enforced between departures within a gap and also between departures in adjacent gaps.

If departure and arrival flight paths are projected to cross, additional wake turbulence separation (currently 2 minutes) through the intersection is required. To analyze this special case, the Delay Simulation Model discussed in Chapter 4 is recommended. These conditions could possibly occur when the distance from the arrival threshold to intersection is less than 2000 feet and the distance from departure threshold to intersection is more than 5000 feet.

2.2.8 Combinations of Models

The models for most of the remaining runway use configurations are combinations of the prime equations discussed above. For example, Model 2-16(M:B,A) in VFR is the sum of the capacity for the Single Runway Model with mixed operations (1-3(B) and the Single Runway Model with arrivals only (1-1(A). Model 13-2(DV:B,B,D) -- three runways intersecting beyond, diverging -- in VMC is made up of the Two Parallel Runway Model with mixed operations for close spaced runways (2-24(C:B,B)) and the Single Runway Model for departures only (1-2(D)).

2.3 Additional Program Logic

The above section described the general logic used to compute runway capacity. The following paragraphs address some of the specific details and assumptions of the calculations.

2.3.1 Arrival Percentage Logic

The equations for computing capacity contained in the previous subparagraphs did not consider the desired percentage of arrivals. These equations were based on arrivals having preemptive priority; the capacity so calculated is therefore referred to as the "arrival-priority" capacity. To arrive at the desired arrival percentage, the following methodology is used:

- o If the arrival-priority capacity provides more departures than needed for the specified arrival percentage, the excess departures are eliminated.

- o If additional departure capacity is required, the "departure-priority" capacity is then calculated. This is obtained by revising the runway configurations, eliminating all arrival streams that may interfere with the departure streams, in order to maximize the number of departures.

- o If the departure-priority capacity provides an excess of departures, the program balances the arrival-priority and departure-priority capacities, operating each for a portion of the hour, in order to obtain the specified arrival percentage.

- o If the departure-priority capacity provides too many arrivals, the excess are eliminated to obtain the desired arrival percentage.

For example, the capacity (without regard to percent arrivals) for a runway configuration is 35 arrivals and 60 departures. If the user had specified 50% arrivals, the program would eliminate the departures in excess of the arrival capacity and list the capacity as 35 arrivals and 35 departures, a total of 70 operations/hour. Twenty-five more departures per hour are possible but are not required for the specified arrival percentage.

For another example, the hourly capacity (without regard to percent arrivals) of a single runway with mixed operations is 35 arrivals and 15 departures.

If the user specified 50% arrivals, the departure-priority capacity would be computed. Eliminating the interfering arrival stream leaves a departures-only runway, with a capacity of (for example) 50 departures per hour. Balancing these two capacities results in 25 arrivals and 25 departures per hour.

The program assumes that individual runways will be used in a way which maximizes total capacity. Any factors which prevent such usage must be recognized, and the program results adjusted accordingly. For example, if a runway configuration consisted of four parallel runways, where two runways were used for mixed operations, one runway was used for arrivals only, and one runway was used for departures only, the capacities might be:

		Capacity	
Runway	Operation	Arrival	Departure
1	Mixed	35	25
2	Mixed	35	20
3	Arrival	35	0
4	Departure	0	60
		105	105

The capacity for all four runways at 50% arrivals is 210. However, if the constraint was imposed to have half the demand on runways 1 and 2 and half on runways 3 and 4, the capacity would be substantially less; i.e., 116 + 70 = 186.

In such cases, it is advisable to calculate the capacity of each runway or dependent runway pair separately and apply the percent arrival technique manually. This procedure is described in Appendix A.

2.3.2 Gap Stretching

In reality, an arrival/departure runway would not be run under arrival-priority for part of the hour and departures-only for the remainder, as the above section implies. Such an apportionment between operating modes is only intended as an approximation of the real world, in which controllers selectively stretch the gaps between arrivals in order to fit in more departures.

This gap stretching can now be modeled more directly by the capacity program. The logic operates as follows: each interarrival gap is stretched by a user-specified increment (e.g. 10 seconds). Departure capacity is then recomputed. If the gap stretch for a particular aircraft pair does not provide a net capacity benefit, the gap is returned to its previous size. Arrival and departure capacities are then calculated and printed for the resulting combination of stretched and unstretched gaps.

For the second gap-stretching, each interarrival gap is stretched by two increments (in this case, 20 seconds), compared to its unstretched size. After testing for net capacity benefit, some gaps might retain the 20 second stretch, others only 10 seconds, and some might not be stretched at all.

The user may specify both the increment used for gap stretching, and the maximum number of additional capacity points to be calculated. It is suggested that increments of 10 to 30 seconds be used. Large gap stretches will not produce the capacity benefit which might be expected, since the program is limited to consider no more than three departures per arrival gap.

2.3.3 First Enqueued Departure Mix

In the process of inserting departures into the arrival gaps, the program compensates for the fact that certain aircraft types are more likely to be released than others. One way this is done is through the first enqueued departure (f.e.d.) mix. If an aircraft is not released in the current interarrival gap, it will be first in the queue to be released in the next gap. An iterative technique which converges quickly is used to determine the f.e.d. mix, PFED(i,k), the probability that a departure of type k will be first in line after an arrival of type i. The maximum number of iterations and the convergence criterion can be user-specified.

This procedure removes most of the potential imbalance between types in the departure mix. Any remaining imbalance is accounted for by basing departure capacity on the most limiting aircraft type. For example, if 24 departures of type A aircraft are possible, and 26 type B departures in an hour, but each type represents 50% of the overall fleet, the departure capacity will be 48 (24/0.5). Otherwise, type A aircraft would be under-represented in the departure mix.

2.3.4 Operating Conditions

The Airfield Capacity Model recognizes three separate weather conditions:

- VMC -- Visual Meteorological Conditions
- IMC -- Instrument Meteorological Conditions
- MMC -- Marginal Meteorological Conditions

In VMC, Visual Flight Rules (VFR) apply; in IMC, Instrument Flight Rules (IFR) are enforced. MMC is basically an IFR environment, but visibility is good enough that the 2.0 nmi departure/arrival separation in IMC is superceded by the application of visual separations. This only affects certain runway configurations, those which include (or are modeled as if they included) a single, mixed-operations runway (1-3(B)) or a close-spaced parallel pair with arrivals on one and departures on the other (2-20(C:A,D) and 2-22 through 2-24). Additionally, the table of runway configurations that will be presented in Section 2.7 will indicate whether separate logic exists for the MMC case.

MMC differs from IMC in another manner as well. It is assumed that two intersecting runways can be used with departures on both in MMC, but in IMC visibility is too poor for the controller to see the intersection, and so departures are conducted on only one runway.

These differences between the weather conditions are summarized in Table 2-1.

2.3.5 Aircraft Mix

In general, the definition of aircraft classes used in the Airfield Capacity Model is at the user's discretion. However, the logic of certain runway models will treat D type aircraft as wake turbulence producing aircraft and apply special wake turbulence air traffic control separation criteria.

This is done in VMC if the configuration includes (or is modeled as if it included) a close-spaced parallel pair with arrivals on both

TABLE 2-1

EXPLANATION OF WEATHER CONDITIONS

WEATHER		VISIBILITY* (STAT. MI.)	CEILING* (FEET)	OPERATIONAL IMPACT
VMC	VISUAL METEOROLOGICAL CONDITIONS	5.0	5000	VISUAL APPROACHES -- PARALLEL RUNWAYS >700' APART ARE INDEPENDENT
MMC	MARGINAL METEOROLOGICAL CONDITIONS	2.5	900	IFR SEPARATIONS APPLY BETWEEN ARRIVALS -- PARALLEL RUNWAYS <4300' APART HAVE DEPENDENT ARRIVAL OPERATIONS -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS >700' APART ARE INDEPENDENT SECAUSE VISUAL SEPARATIONS ARE APPLIED
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS	0.0	0	ALL IFR PROCEDURES ARE IN EFFECT -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS <2500' APART ARE DEPENDENT

*THESE ARE VALUES WHICH ARE INPUT TO THE PROGRAM, NOT BREAKPOINTS BETWEEN WEATHER CONDITIONS

or departures on both (2-19(C:A,A) and 2-21 through 24). The logic for such cases has been discussed in Section 2.2.4.

This same assumption about D-type aircraft is made for intersecting runways with departures on both in VMC and MMC, because of the need to provide proper wake vortex protection if both aircraft are airborne at the intersection. (See Section 2.2.7.)

The mix of aircraft types is specified for each runway. Unless specific restrictions apply, the mix on each runway is generally the same. If the mixes differ, care must be taken that the capacity results do not distort the overall airport mix. For example, the capacity of a short, general-aviation runway may be 37 operations per hour, but if general aviation only constitutes 10% of the total airport mix, it is doubtful that the full capacity of the runway will be utilized. On the other hand, the addition of such a runway may increase the general aviation traffic at the airport to more than 10% of the total. Such questions must be resolved by the model user, outside the model itself.

In some cases the individual runway mixes are not used, but rather the mixes on two runways are averaged together. This occurs in MMC and IMC for close parallel runways with arrivals on both (2-19(C:A,A)) or with departures on both (2-21(C:D,D)). The assumption is that such operations, being dependent under Instrument Rules, will be conducted on a single runway.

2.3.6 Minimum Arrival Separation

The input parameter DLTAIJ is defined as the "minimum" separation between a pair of arrivals over the length of their common approach path. The Airfield Capacity Model converts the minimum arrival separation into an average arrival-arrival separation over threshold by the following formula:

Average Separation Over Threshold = (Minimum Separation) + (Control System Buffer) + (Velocity Differential)

The average arrival-arrival separation over threshold (AASR(i,j)) is used by the Airfield Capacity Model in the computation of capacity. The minimum arrival-arrival separation DLTAIJ is one factor in determining the average arrival-arrival separation over threshold.

There are several ways to look at the meaning of DLTAIJ and AASR.

DLTAIJ can be regarded as the air traffic control separations specified in 7110.65B "Air Traffic Control Handbook." These are IFR separations; under VFR, visual separations (which are not as great) would apply. Suggested values for minimum VMC separations, as well as IFR and VFR separations for future ATC environment, may be found in FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay."

Alternatively, the actual observed separations over the threshold can be used to determine AASR and therefore DLTAIJ. The use of observed data should be approached cautiously in order to avoid:

- o small sample sizes
- o non-representative operating conditions
- o non-saturated demand

any of which would distort the results. (Appendix A of FAA-EM-78-8A provides some additional guidelines for the use of observed data.) Methods for converting AASR(i,j) values into DLTAIJ(i,j) values or DLTAIJ(i,j) values into AASR(i,j) values are described in Appendix B.

2.4 Input Format

2.4.1 General Information

This section will describe, line-by-line, the requirements for constructing an input file for the Airfield Capacity Model. The following general information applies:

- o Each input item consists of two lines, the header card and the data card, e.g.,

```
RUNWAY 2 1 0                (header)
0.250.250.250.25            (data).
```

- o There is no fixed sequence for groups of header/data cards.
- o Each header card contains the following data:

cc 1-6	NAME	(A6)	arbitrary title for identifying each data item, e.g., RUNWAY
cc 8	IRUM	(I2)	runway number, when needed

cc 9-10	INDEX	(I2)	input data type number
cc 12	NCARD	(I2)	execution command -- 1 if the last input item for a run, otherwise 0 or blank
cc 13-80	ALPHA	(A68)	available for comments by user -- must start prior to cc 20.

- If there are four items on a data line, one for each aircraft class, they should be input in order, from the smallest class to the largest:

  A B C D

- If there are sixteen items on a data line (4 classes for the lead aircraft and 4 for the trailing), they should be entered as follows:

  AA AB AC AD BA BB BC BD CA CB CC CD DA DB DC DD

  where AB indicates a class A aircraft followed by a class B.

- To execute a run, the value of NCARD is 1. Additional cases can be run with a single input file by placing additional lines, for the items to be added or changed, after the last line for the first case. The last input item for each case must have NCARD = 1 on the header line.

- The number of cases which can be contained in a single data file is almost unlimited; however, long data files increase the risk of losing track of the current values of the variables.

A sample coding form illustrating the format for the input items is shown in Figure 2-2. Examples of typical input files will be shown in Section 2.8.

2.4.2 Specific Data Items

Although each header card has the same format, the format of each data card depends on the type of data it contains. The following section will describe in detail the variables and format of each data card. The data lines will be referred to by the NAME assigned by the interactive section of the program and by the INDEX number. The user may change the NAME, but cannot change the INDEX.

1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	53–56	57–60	61–64
NEWR	UN	0 0		text											
imodel	istrgy	ialt													
RUNW	AY 1	1		text											
a .	b .	c .	d .												
RUNW	AY 2	1		text											
a .	b .	c .	d .												
ARBA	R2 1	2													
a .	b .	c .	d .												
ARBA	R2 2	2													
a .	b .	c .	d .												
DLTA	IJ	4													
aa .	ab .	ac .	ad .	ba .	bb .	bc .	bd .	ca .	cb .	cc .	cd .	da .	db .	dc .	dd .
APPS	PD	5													
a	b	c	d												
DRBA	R	6													
a	b	c	d												
TD		7													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd

FIGURE 2-2
SAMPLE INPUT CODING FORM

1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	53–56	57–60	61–64
GAMMA		8													
a	b	c	d												
TGRBAR		9													
a	b	c	d												
OPENV		10													
theta	opeuvx	adsrx	dicbrx												
TWOIN		11													
iax	sigai	sigdi	txi(a,1)	(b,1)	(c,1)	(d,1)	(a,2)	(b,2)	(c,2)	(d,2)					
ADSR		12													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
DICBR		13													
aa	ab	a	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd
SIGMAS		19													
sigmar	sigmaa	sigtgr	sigmac	sigmdr											
OTHERS		20													
pv	pwi	dltada	vis	ceilng	gslope	petg	ipsf1	ipsf2	etc.	[up to	11 values]				
BDD		22													
aa	ab	ac	ad	ba	bb	bc	bd	ca	cb	cc	cd	da	db	dc	dd

FIGURE 2-2
SAMPLE INPUT CODING FORM
(Cont.)

1–4	5–8	9–12	13–16	17–20	21–24	25–28	29–32	33–36	37–40	41–44	45–48	49–52	53–56	57–60	61–64
BAA		24													
aa .	ab .	ac .	ad .	ba .	bb .	bc .	bd .	ca .	cb .	cc .	cd .	da .	db .	dc .	dd .
ALTARR		25													
diagsp .	cldist	.	thdisp .	gtdisp .											
INCIAT		26													
jbomb	. cav	inst	delist .												

FIGURE 2-2
SAMPLE INPUT CODING FORM
(Cont.)

The format for each variable is shown in FORTRAN notation. I4 indicates four columns of integer data (a decimal point should not be used). F4.1 indicates four columns of floating-point data with one place to the right of the decimal point; however, the program will correctly read the input regardless of the location of the decimal.

<u>NEWRUN---0</u>

IMODEL - (I4)	cc 1-4	- the model number (1 to 15) of the runway configuration to be studied, e.g., 1 (single runway), 6 (two intersecting).
ISTRGY - (I4)	cc 5-8	- the operational strategy. Together, IMODEL and ISTRGY determine the configuration, e.g., 1-3 means mixed operations on a single runway. - details of all the available model and strategy combinations are presented in Section 2.7.1.
IALT - (I4)	cc 9-12	- indicates whether alternating arrivals are to be conducted to parallel runways. - 0 indicates no stagger is to be run, 1 indicates alternating arrivals are to be conducted, if the runways are 3000 feet apart or more.

<u>RUNWAY---1</u>

PHR (I,IRUM) - (4F4.2)		- proportion of aircraft type I on runway IRUM (4 values, smallest aircraft type first). - must be input for each runway in the configuration--specify IRUM on the header line.

<u>ARBAR2----2</u>

ARBAR (IRUM,I) - (4F4.0)		- average arrival runway occupancy time of aircraft type I on runway IRUM (4 values).

- must be input for each arrival runway in the configuration.
- if the average times are not known, estimates can be obtained by using the technique of Section 2.7.2.

EXITPT---3 - No longer used in the revised version

DLTAIJ---4

DLTAIJ (I,J) - (16F4.1) - minimum arrival separations, in nmi, for aircraft type J following type I.

APPSPD---5

V(I) - (4I4) cc 1-16 - final approach speed, in knots, for class I (4 values).

DRBAR----6

DRBAR(I) - (4I4)
- average departure runway occupancy time, in seconds, for class I (4 values).
- Time from start of roll to liftoff.

TD-------7

DDSR(I,J) - (16I4) - minimum departure separations, in seconds, for class J behind class I (16 values)

GAMA-----8

GAMA(I) - (4I4)
- length of final approach path, in nmi, for class I (4 values).
- same values are used for all arrival runways.
- for alternating arrivals, enter values for runway 1 (see GTDISP).

TGRBAR---9

TGRBAR(I) - (4F4.0)		-	touch-and-go runway occupancy time, in seconds, for class I (4 values).
		-	not needed if POTG (see OTHERS--20) is zero.

OPENV---10 - needed for models 5, 10, 11, 12, 13, 14

THETA - (I4)	cc 1-4	-	angle, in degrees, between two open V runways.
OPENVX - (I4)	cc 5-8	-	distance, in feet, between the thresholds of the two open-V runways.
ADSRX - (F4.1)	cc 9-12	-	see ADSR----12. If ADSRX is non-zero, ADSR(I,J) is set equal to ADSRX for all I and J. Otherwise ADSR(I,J) is set to 10 seconds.
DICBRX - (F4.1)	cc 13-16	-	see DICBR---13. Similarly to ADSRX, DICBR(I,J) is set equal to DICBRX or 2.0 nmi.

TWOIN---11 - needed for models 6-1, 6-3, 7-1, 7-2 (also 6-2 if SIGAI and SIGDI are non-zero).

IAX - (I4)	cc 1-4	-	airborne intersection indicator.
		-	0 means aircraft are not airborne at intersection. 1 means aircraft are airborne at intersection and special vortex separations apply.
SIGAI - (F4.1)	cc 5-8	-	the standard deviation of the time for arrivals to clear the intersection, in seconds.
SIGDI - (F4.1)	cc 9-12	-	the standard deviation of the time for departures to clear the intersection, in seconds.

TXI(I,K) - (8F4.0) cc 13-44 - the average time, in seconds, for a departure of class I, on runway K, to clear the intersection.
- 4 values for runway 1, followed by 4 values for runway 2.
- does not apply to model 6-2 (may be left blank).

ADSR----12 - needed for models 5-4, 5-5, 6-2, 6-3, 7-1, 7-2, 11-3, 11-4, 12-3, 12-4, 14-3, 14-4, 15-1, 15-2.

ADSR(I,J,IRUM) - (16F4.0) - the separation, in seconds, between arrival I on runway IRUM and departure J on the crossing runway (16 values).
- generally, this is the time after I crosses the threshold at which J can be released.

DICBR---13 - also needed for models 5-4, 5-5, 6-2, 6-3, 7-1, 7-2, 11-3, 11-4, 12-3, 12-4, 14-3, 14-4, 15-1, 15-2.

DICBR(I,J) - (16F4.1) - the separation, in nmi, between departure I and arrival J on the crossing runway (16 values).
- generally, the minimum distance of J from the runway threshold at which I can be released.

14 to 18 - no longer used. These items were originally associated with the gate and taxiway capacity models, which have been dropped.

SIGMAS--19

SIGMAR (F4.0) cc 1-4 - standard deviation, in seconds, of arrival runway occupancy time (R.O.T.).

SIGMAA (F4.0) cc 5-8 - standard deviation, in seconds of interarrival time.

SIGTGR (F4.0) cc 9-12 - standard deviation, in seconds of touch and go R.O.T.s.

SIGMAC (F4.0)	cc 13-16	- standard deviation in seconds of cleared-to-roll time.
SIGMDR (F4.0)	cc 17-20	- standard deviation, in seconds of departure R.O.T.

<u>OTHERS--20</u>

PV - (F4.2)	cc 1-4	- probability of violation for arrival R.O.T., etc. Usually 0.05.
PVI - (F4.2)	cc 5-8	- probability of violation for interarrival time only. Usually 0.05 for the present, 0.01 for future cases.
DLTADA - (F4.1)	cc 9-12	- departure/arrival separation, in nmi. The minimum distance of an arrival from the runway threshold in order to release a departure on the same or a close-spaced parallel runway.
VIS - (F4.1)	cc 13-16	- visibility, in statute miles.
CEILNG - (I4)	cc 17-20	- ceiling, in feet.
GSLOPE - (F4.1)	cc 21-24	- glide slope angle, in degrees.
POTG - (F4.2)	cc 25-28	- proportion of touch and go operations. - since a T&G is counted as both an arrival and a departure, POTG must be no greater than twice the arrival percentage or twice the departure percentage. - if POTG is greater than zero, specify only one value for IPA, the arrival percentage.
IPA - (11I4)	cc 29-72	- up to 11 different arrival percentages. - the first arrival percentage may also take on three special values:

- o 9999 - only arrival priority capacity is calculated.
- o 8888 - arrival priority and departure priority capacities are calculated.
- o 7777 - capacity will be calculated for arrival priority, for the maximum number of gap-stretching intermediate points (as specified in INCIAT--26), and for departure priority.

- if these special values are used other than in the first position, they will be ignored.

21 - not used

BDD-----22

BDD(I,J) - (16F4.0) - buffer time, in seconds, between simultaneous departures on close-spaced parallel runways (16 values).

23 - the logic supported by this input has been superceded by the gap-stretching logic (see INCIAT--26).

BAA-----24

BAA(I,J) - (16F4.0) - buffer time, in seconds, between simultaneous arrivals to close-spaced parallel runways (16 values).

ALTARR---25

DIAGSP - (F4.1) cc 1-4 - diagonal separation, in nmi, to be applied between consecutive, alternating arrivals to parallel runways.

- if DIAGSP is any negative value DLTAIJ(I,J) is used for the diagonal separation between I and J on different runways.

CLDIST - (F6.0) cc 5-10 - separation between runway centerlines, in feet.

THDISP - (F6.0) cc 11-16 - displacement of runway thresholds. This is measured from the threshold of runway 1, in the direction of flight. THDISP is, therefore, negative if the r/w2 threshold is reached before the r/w1 threshold.

GTDISP - (F4.1) cc 17-20 - the relative displacement, in nmi, of the gates for the two runways, the start of the final approach paths. Again, this is measured forward (positive) or back (negative) from the r/w1 gate.

To run alternating arrivals, both the ALTARR data and IALT (on line 0, NEWRUN) should be provided for each case. If both are not provided, the following defaults occur:

- o If IALT > 0 but ALTARR data is not entered, the program assumes

  DIAGSP = 2.0
  CLDIST = 3000.
  THDISP = 0.
  GTDISP = 0.

- o If ALTARR data is entered but IALT is not, IALT = 1 is assumed.

- o If neither IALT nor ALTARR are entered, but the runway capacity would benefit from alternating arrivals (e.g., model 2-7(M:A,A)), the program operates alternating arrivals using a 3.0 nmi (actually, DLTAIJ (1,1)) intrail separation.

To force such an intrail (not diagonal) separation, set IALT = 2 and CLDIST = 0.

INCIAT--26

JBOMB - (I4)	cc 1-4	-	the maximum number of iterations on the f.e.d. mix.
CNV - (F4.3)	cc 5-8	-	the convergence criterion for f.e.d. mix iterations. If the absolute difference between the old and the new PFED(I,K), for each I and K, is less than CNV, iteration will stop.
INST - (I4)	cc 9-12	-	the maximum number of points for which arrival capacity is calculated (the arrival-priority point plus INST-1 intermediate points).
DELIAT - (F4.0)	cc 13-16	-	the increment, in seconds, by which the arrival gaps are stretched to obtain the intermediate points.

If this line is not input, these values default to

- o JBOMB = 1
- o CNV = 0.05
- o INST = 2
- o DELIAT = 20 seconds.

2.5 Output

The principal output of the Airfield Capacity Model is the total capacity per hour for a specified arrival percentage. This capacity is without regard to delay considerations.

The program first prints out the capacity values - arrival-priority, departure-priority, plus any intermediate points resulting from gap stretching - which were used to compute the resulting capacity. For each such point, the arrival and departure capacity at that point are printed; for each intermediate point, the maximum "stretch" added to each gap is also printed.

Next, the program will print the means by which the specified arrival percentage is achieved. One of the following messages will be printed:

TO OBTAIN 100 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY 26.2 OPERATIONS PER HOUR

- the arrival-priority capacity contains an excess number of departures (no additional arrivals are possible)

TO OBTAIN 50 PERCENT ARRIVALS, OPERATE
AT POINT 1 FOR 76 PERCENT OF THE HOUR,
AND AT POINT 2 FOR 24 PERCENT

- point 1 (arrival-priority) contains an excess of arrivals, and point 2 (the first gap-stretching point) contains too few arrivals to satisfy the desired arrival percentage, so the program interpolates between them.

TO OBTAIN 75 PERCENT ARRIVALS, OPERATE
AT POINT 3 FOR 31 PERCENT OF THE HOUR, AND
AT DEPARTURE PRIORITY POINT FOR 69 PERCENT

- point 3 (the last gap-stretching point, in this case) contains more arrivals than required, so the program interpolates between this point and the departure priority point.

TO OBTAIN 0 PERCENT ARR, INTERFERING ARRIVAL STREAMS ARE ELIMINATED,
AND REMAINING ARRIVAL CAPACITY IS REDUCED BY 19.6 OPERATIONS PER HOUR

- even with departure-priority, some arrivals remain. These excess arrivals are dropped to achieve the desired arrival percentage.

If the desired arrival percentage is satisfied exactly at one of the capacity points, the message printed will be

ARRIVAL PRIORITY CONFIGURATION PROVIDES DESIRED PERCENT ARRIVALS

or similar.

This message is then followed by the airfield capacity at the desired percentage of arrivals.

Certain runway configuration will result in additional messages. For example, if alternating arrivals are being run, either

ALTERNATING APPROACHES -- x NMI DIAGONAL/y FT

or

ALTERNATING APPROACHES -- x NMI INTRAIL SEPARATION

will be printed, where x is the minimum separation in use and y is the distance between runway centerlines.

Also, certain intersecting runway configurations are evaluated with traffic on both runways and with all traffic on just one runway. The operating mode with the greater capacity is chosen, and the message is printed that "ARR ON #1, DEP ON #2 ... " or "MIXED, SINGLE RUNWAY PROVIDES GREATER CAPACITY."

Examples of the output format will be found in Section 2.8.

2.6 Running the Programs

To run the FAA Airfield Capacity Program, two input modes are possible:

- o Remote Job Entry (RJE) using cards
- o using an interactive terminal and stored input files.

Remote job entry (also called batch processing) requires that all data be punched on cards. Additional cards are required to load the capacity model and to identify the user for billing purposes. Output is directed to a remote printer.

In the terminal mode, the user can construct input files and run the program directly from his work area. The input format is exactly the same as with cards. Ouput may be returned to a printer or directly to the terminal, or both.

The terminal mode also makes interactive data entry possible. This method, which will be explained in Chapter 3, involves responding to specific questions as they are asked by the program.

Details of loading and executing the program will vary at different installations. However, we can illustrate a typical procedure using the technique for the CDC system. In this system, the user merely enters at his terminal

-CAPRUN(FN = filename

where filename is the name of the input file. If a file named "filename" exists, it will be used as input to the program; output will be returned to the terminal. The input file may be created by direct entry from the terminal or by editing a previously existing file. If "filename" does not exist, the program will enter the interactive mode. The input file created from the answers to the interactive questions will be stored, after execution, under the name "filename". If the user does not want to save this file, the command

PURGE, filename

will erase the file.

The FAA Airfield Capacity Program has been written in a version of Fortran IV which is compatible with the Control Data Corporation (CDC) timesharing system. Minor changes might be needed to install the program on other systems, but all attempts have been made to keep such changes to a minimum.

For example, the CDC version of Fortran IV is known to differ from the IBM version in at least the following areas:

- o FORMAT statements for literal data
- o standard length of REAL variables
- o end-of-file condition on a READ statement.

The program consists of almost 3000 lines of source code, comprising 25 subroutines. The compiled version is also almost 3000 lines long on CDC (or about 3300 lines on an IBM system). To load and execute the program requires approximately an additional 200K bytes of memory.

2.7 Additional Information

This section presents some information, in tabular form, which might be useful to the person who wishes to run the Airfield Capacity Model.

2.7.1 Model/Strategy Combinations

The Capacity Model contains 13 different basic runway configurations, or models, as shown in Figure 2-1. Each of these models has a number of operating strategies (from 3 to 26) associated with it as well. Each strategy corresponds to a particular pattern of arrival and departure usage of the available runways, and may contain some information about the runway geometry itself (such as spacing between parallel runways and direction of operation on non-parallel runways).

Table 2-2 presents all the model and strategy combinations currently supported by the Airfield Capacity Model. Certain assumptions have been made in developing these particular combinations:

- In all configurations with three runways (except intersecting), runways 1 and 2 are always close-spaced. The separation between runways 2 and 3 is specified by the strategy.

- The spacing between parallel runways 1 and 3 is assumed to be related to the spacing between runways 2 and 3, as follows:

Runways 2 and 3	Runways 1 and 3
700-2499 ft (close)	2500-4299 ft (medium)
2500-3499 ft (near)	3500-4299 ft (medium)
3500-4299 ft (medium)	4300 ft or more (far)
4300 ft or more (far)	4300 ft or more (far)

- In all four runway configurations, runways 1 and 2 and runways 3 and 4 are assumed to be close-spaced parallels.

- A radar environment is assumed. Two non-intersecting runways are therefore considered parallel if the angle between them is less than 15°. The variable IR is used in the program and in Table 2-2 to specify the degree of dependence between two non-intersecting runways, as follows:

IR	Angle	Distance Between Thresholds	Interpretation
0	<15°	700-2499 ft	close parallel
1	<15°	2500-4299 ft	medium parallel
2	<15°	4300 ft or more	far parallel
3	≥15°	greater than zero	non-parallel

Table 2-2 also indicates the manner in which the program calculates the arrival-priority capacity of each configuration. Most capacities are simply the total of the capacities of the individual runways, or groups of runways, within the configuration. "Primary equation"

TABLE 2-2

RUNWAY MODELS AND STRATEGIES

SINGLE RUNWAY		
MODEL	WEATHER	CAPACITY
1-1 (A)	all	primary equation
1-2 (D)	all	primary equation
1-3 (B)	all	1-1(A) plus interleaved departures
1-4* (B)		1-3(B) with predetermined inter-arrival times

TWO PARALLEL RUNWAYS		
2-1 (F:A,A)	all	1-1(A) + 1-1(A)
2-2 (F:A,D)	all	1-1(A) + 1-2(D)
2-3 (F:D,D)	all	1-2(D) + 1-2(D)
2-4 (F:B,A)	all	1-3(B) + 1-1(A)
2-5 (F:B,D)	all	1-3(B) + 1-2(D)
2-6 (F:B,B)	all	1-3(B) + 1-3(B)
2-7 (M:A,A)	VMC	1-1(A) + 1-1(A)
	MMC/IMC	dependent arrivals, no vortex
2-8 (M:A,D)	all	1-1(A) + 1-2(D)
2-9 (M:D,D)	all	1-2(D) + 1-2(D)
2-10 (M:B,A)	VMC	1-3(B) + 1-1(A)
	MMC/IMC	2-7(M:A,A) plus departures

C -- close (700-2499 ft)
N -- near (2500-3499 ft)
M -- medium (2500-4299 ft)
F -- far (4300 ft or more)

A -- arrivals only
D -- departures only
B -- both arrivals and departures

*new model, only called by model 3-5(N:A,D,B)

TABLE 2-2 (Cont.)

TWO PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
2-11 (M:B,D)	all	1-3(B) + 1-2(D)
2-12 (M:B,B)	VMC	1-3(B) + 1-3(B)
	MMC/IMC	2-7(M:A,A) plus departures on both
2-13 (N:A,A)		see 2-7 (M:A,A)
2-14 (N:A,D)		see 2-8 (M:A,D)
2-15 (N:D,D)		see 2-9 (M:D,D)
2-16 (N:B,A)		see 2-10 (M:B,A)
2-17 (N:B,D)		see 2-11 (M:B,D)
2-18 (N:B,B)		see 2-12 (M:B,B)
2-19 (C:A,A)	VMC	independent arrivals with vortex
	MMC/IMC	1-1 (A1) with average mix
2-20 (C:A,D)	VMC/MMC	1-1(A) + 1-2(D)
	IMC	dual-lane primary equation--DUAL(1)
2-21 (C:D,D)	VMC	independent departures with vortex
	MMC/IMC	1-2(D1) with average mix
2-22 (C:B,A)	VMC	1-3(B) + 1-1(A) with vortex
	MMC	1-1(A2) + 1-2(D1)
	IMC	2-20(C:A2,D1)
2-23 (C:B,D)	VMC	1-3(B) + 1-2(D) with vortex
	MMC	1-1(A) + 1-2(D)
	IMC	2-20(C:A,D)
2-24 (C:B,B)	VMC	1-3(B) + 1-3(B) with vortex
	MMC	1-1(A) + 1-2(D)
	IMC	2-20(C:A,D)

TABLE 2-2 (Cont.)

THREE PARALLEL RUNWAYS

MODEL		WEATHER	CAPACITY
3-1	(C:B,B,B)	VMC	1-3(B) + 1-3(B) + 1-3(B) with vortex
		MMC/IMC	2-12(M:B1,B3)
3-2	(N:B,B,B)	VMC	2-24(C:B1,B2) + 1-3(B3)
		MMC	1-2(D2) + 2-10(M:B3,A1)
		IMC	3-5(N:A,D,B)
3-3	(M:B,B,B)	VMC	2-24(C:B1,B2) + 1-3(B3)
		MMC/IMC	2-20(C:A,D) + 1-3(B3)
3-4	(C:A,D,B)	VMC	1-1(A) + 2-23(C:B3,D2)
		MMC	1-2(D2) + 2-7(M:A1,A3)
		IMC	3-17(C:A,D,A)
3-5	(N:A,D,B)	VMC	1-1(A) + 1-2(D) + 1-3(B)
		MMC	2-10(M:B3,A1) + 1-2(D2)
		IMC	2-7(M:A1,A3) + D3 from 1-4(B3) + D2 from DUAL(2,A,D)*
3-6	(F:A,D,B)	all	2-20(C:A,D) + 1-3(B)
3-7	(N:B,B,A)	VMC	2-24(C:B,B) + 1-1(A3)
		MMC	2-7(M:A1,A3) + 1-2(D2)
		IMC	2-7(M:A1,A3) + D2 from DUAL(2,A,D)*

A2 -- Arrivals only on runway 2

D3 -- Departures only on runway 3

*new model -- dual-lane operations with alternating arrival inputs

TABLE 2-2 (Cont.)

THREE PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
3-8 (F:B,B,A)	VMC	2-24(C:B,B) + 1-1(A3)
	MMC/IMC	2-20(C:A,D) + 1-1(A3)
3-9 (N:A,B,B)	VMC	2-22(C:B2,A1) + 1-3(B3)
	MMC	2-7(M:A1,A3) + 1-2(D2)
	IMC	3-5(N:A,D,B)
3-10 (F:A,B,B)	all	2-20(C:A,D) + 1-3(B3)
3-11 (M:B,A,D)	all	2-22(C:B,A) + 1-2(D3)
3-12 (F:B,A,D)	all	2-22(C:B,A) + 1-2(D3)
3-13 (M:D,A,B)	VMC	2-20(C:A2,D1) + 1-3(B3)
	MMC	2-10(M:B3,A2) + 1-2(D1)
	IMC	3-5(N:A2,D1,B3)
3-14 (F:D,A,B)	all	2-20(C:A2,D1) + 1-3(B3)
3-15 (M:A,D,A)	all	2-20(C:A,D) + 1-1(A3)
3-16 (F:A,D,A)	all	2-20(C:A,D) + 1-1(A3)
3-17 (C:A,D,A)	VMC	2-20(C:A,D) + 1-1(A3)
	MMC	2-7(M:A1,A3) + 1-2(D2)
	IMC	2-7(M:A1,A3) + D2 from DUAL(3,A,D)*
3-18 (C:D,A,B)	VMC	2-22(C:B3,A2) + 1-2(D1)
	MMC	2-9(M:D1,D3) + 1-1(A2)
	IMC	3-25(C:D,A,D)
3-19 (C:B,A,D)	all	see 3-18 (C:D3,A2,B1)
3-20 (C:A,B,B)	VMC	1-1(A1) + 1-3(B2) + 1-3(B3) with vortex
	MMC	2-7(M:A1,A3) + 1-2(D2)
	IMC	3-17(C:A,D,A)

*new model -- dual lane operations with alternating arrival input

TABLE 2-2 (Cont.)

THREE PARALLEL RUNWAYS

MODEL	WEATHER	CAPACITY
3-21 (C:B,B,A)	all	see 3-20(C:A3,B2,B1)
3-22 (C:A,D,D)	VMC/MMC	2-21(C:D2,D3) + 1-1(A1)
	IMC	2-8(M:A1,D3)
3-23 (M:A,D,D)	VMC/MMC	2-9(M:D2,D3) + 1-1(A1)
	IMC	2-20(C:A,D) + 1-2(D3)
3-24 (F:A,D,D)	VMC/MMC	2-3(F:D2,D3) + 1-1(A1)
	IMC	2-20(C:A,D,) + 1-2(D3)
3-25 (C:D,A,D)	VMC/MMC	2-3(F:D1,D3) + 1-1(A2)
	IMC	2-20 (C:A2,D1) + D3 from 2-20 (C:A2,D3)
3-26 (M:D,A,D)	VMC/MMC	1-2(D1) + 1-1(A2) + 1-2(D3)
	IMC	2-20(C:A2,D1) + 1-2(D3)
3-27 (F:D,A,D)	all	see 3-26 (M:D,A,D)
3-28 (C:D,D,D)	VMC	1-2(D1) + 1-2(D2) + 1-2(D3) with vortex
	MMC/IMC	2-9(M:D1,D3)
3-29 (M:D,D,D)	all	2-21(C:D,D) + 1-2(D3)

TABLE 2-2 (Cont.)

FOUR PARALLEL RUNWAYS

MODEL		WEATHER	CAPACITY
4-1	(M:D,A,D,A)	all	2-20(C:A2,D1) + 2-20(C:A4,D3)
4-2	(F:D,A,D,A)	all	see 4-1(M:D,A,D,A)
4-3	(M:A,D,D,A)	all	2-20(C:A,D) + 2-20(C:A4,D3)
4-4	(F:A,D,D,A)	all	see 4-3(M:A,D,D,A)
4-5	(M:A,D,D,B)	all	2-20(C:A,D) + 2-23(C:B4,D3)
4-6	(F:A,D,D,B)	all	see 4-5(M:A,D,D,B)
4-7	(M:D,A,D,B)	all	2-20(C:A2,D1) + 2-23(C:B4,D3)
4-8	(F:D,A,D,B)	all	see 4-7(M:D,A,D,B)
4-9	(M:B,A,A,D)	VMC	2-22(C:B,A) + 2-20(C:A3,D4)
		MMC/IMC	1-3(B1) + 2-20(C:A3,D4)
4-10	(F:B,A,A,D)	all	see 4-9 (M:B,A,A,D)
4-11	(M:B,A,D,A)	all	2-22(C:B,A) + 2-20(C:A4,D3)
4-12	(F:B,A,D,A)		see 4-11(M:B,A,D,A)
4-13	(M:B,B,A,D)	all	2-24(C:A,D) + 2-20(C:A3,D4)
4-14	(F:B,B,A,D)	all	see 4-13(M:B,B,A,D)
4-15	(M:B,A,D,B)	all	2-22(C:B,A) + 2-23(C:B4,D3)
4-16	(F:B,A,D,B)	all	see 4-15(M:B,A,D,B)
4-17	(M:B,B,A,B)	all	2-24(C:B,B) + 2-22(C:B4,A3)
4-18	(F:B,B,A,B)	all	see 4-17(M:B,B,A,B)
4-19	(M:B,B,B,B)	all	2-24(C:B,B) + 2-24(C:B3,B4)
4-20	(F:B,B,B,B)	all	see 4-19(M:B,B,B,B)
4-21	(M/F:D,A,D,D)	all	2-20(C:A2,D1) + 2-21(C:D3,D4)
4-22	(M/F:A,D,D,D)	all	2-20(C:A,D) + 2-21(C:D3,D4)
4-23	(F:D,A,A,D)	all	2-20(C:A2,D1) + 2-20(C:A3,D4)
4-24	(M/F:D,D,D,D)	all	2-21(C:D,D) + 2-21(C:D3,D4)
4-25	(M:D,A,A,D)	VMC	2-20(C:A2,D1) + 2-20(C:A3,D4)
		MMC	1-2(D) + 2-7(M:A2,A3) + 1-2(D4)
		IMC	2-7(M:A2,A3) + D1 from DUAL(2, A2,D1) + D4 from DUAL(2,A3,D4)*

TABLE 2-2 (Cont.)

TWO OPEN-V RUNWAYS

MODEL	WEATHER	IR	CAPACITY
5-1 (DV*:D,D)	all	0	2-21(C:D,D)
		>0	1-2(D1) + 1-2(D2)
5-2 (DV:A,D)	VMC/MMC	all	1-1(A1) + 1-2(D2)
	IMC	0	2-20(C:A,D)
		>0	1-1(A1) + 1-2(D2)
5-3 (DV:B,D)	VMC	0	2-23(C:B,D)
		>0	1-3(B1) + 1-2(D2)
	MMC/IMC	0	2-20(C:A,D)
		>0	1-3(B1) + 1-2(D2)
5-4 (CV*:D,A)	VMC/MMC	all	1-2(D1) + 1-1(A2)
	IMC	0	2-20(C:A2,D1)
		1,2	1-2(D1) + 1-1(A2)
		3	6-2(A2,D1)
5-5 (CV:B,A)	VMC	0	2-22(C:B,A)
		>0	1-3(B1) + 1-1(A2)
	MMC	0,3	1-2(D1) + 1-1(A2)
		1	2-10(M:B,A)
		2	1-3(B1) + 1-1(A2)
	IMC	0	2-20(C:A2,D1)
		1	2-10(M:B,A)
		2	1-3(B1) + 1-1(A2)
		3	6-2(A,D)

*DV - diverging
CV - converging

TABLE 2-2 (Cont.)

<u>TWO INTERSECTING RUNWAYS</u>

MODEL	WEATHER	CAPACITY
6-1 (D,D)	VMC/MMC	max [primary equation, 1-2(D) with average mix]
	IMC	1-2(D) with average mix
6-2 (A,D)	all	primary equation
6-3 (B,D)	all	max [5-2(A,D), 1-3(B)]

<u>THREE INTERSECTING RUNWAYS</u>

MODEL	WEATHER	CAPACITY
7-1 (C:A,D,D)	VMC	2-20(C:A,D)
	MMC/IMC	max [2-20(C:A,D), 6-2(A,D)]
7-2 (M:A,D,D)	all	2-8(M:A,D)
7-3 (C:B,B,D)	VMC	2-24(C:B,B)
	MMC/IMC	max [2-20(C:A,D), 6-2(A,D)]
7-4 (M:B,B,D)	all	2-12(M:B,B)

*DV - diverging

CV - converging

TABLE 2-2 (Cont.)

THREE OPEN-V RUNWAYS

MODEL	WEATHER	IR	CAPACITY
10-1 (DV*:B,A,D)	VMC	all	2-22(C:B,A) + 1-2(D3)
	MMC/IMC	0	3-25(C:D,A,D
		>0	2-20(C:A,D) + 1-2(D3)
10-2 (DV:B,B,D)	VMC	0	2-22(C:B,A) + 1-2(D3)
		>0	2-24(C:B,B) + 1-2(D3)
	MMC/IMC	all	see 10-1(DV:B,A,D)
10-3 (CV*:B,D,A)	VMC	all	2-23(C:B,D) + 1-1(A3)
	MMC	0	2-7(M:A1,A3) + 1-2(D2)
		1,2	d < 3500: 2-7(M:A1,A3) + 1-2(D2)
			d ≥ 3500: 1-1(A1) + 1-2(D2) + 1-1(A3)
		3	2-21(C:D,D) + 1-1(A3)
	IMC	0	3-4(C:A,D,A)
		1,2	d < 3500: 3-7(N:A,D,A)
			d ≥ 3500: 2-20(C:A,D) + 1-1(A3)
		3	2-20(C:A,D)
10-4 (CV:B,B,A)	VMC	all	2-24(C:B,B) + 1-1(A3)
	MMC/IMC	all	see 10-3(CV:B,D,A)
10-5 (DV:D,A,D)	VMC	all	2-20(C:A2,D1) + 1-2(D3)
	MMC/IMC	all	see 10-1(DV:B,A,D)

*DV - diverging

CV - converging

TABLE 2-2 (Cont.)

FOUR OPEN-V RUNWAYS

MODEL	WEATHER	IR	CAPACITY
11-1 (DV*:A,A,D,D)	VMC	all	2-19(C:A,A) + 2-21(C:D3,D4)
	MMC	all	2-20(C:A2,D3), average mix
	IMC	0	2-20(C:A2,D3), average mix
		>0	1-1(A2) + 1-2(D3), average mix
11-2 (DV:B,B,D,D)	VMC	0	2-22(C:B,A) + 2-21(C:D3,D4)
		>0	2-24(C:B,B) + 2-21(C:D3,D4)
	MMC/IMC	all	2-20(C:A,D) + 2-21(C:D3,D4)
11-3 (CV*:A,A,D,D)	VMC	all	2-19(C:A,A) + 2-21(C:D3,D4)
	MMC	all	2-20(C:A3,D3), average mixes
	IMC	<3	2-19(C:A,A) + 2-21(C:D3,D4)
		3	6-2(A2,D3)
11-4 (CV:B,B,D,D)	all	all	see 11-3(CV:A,A,D,D)

TWO RUNWAYS INTERSECTING BEYOND

MODEL	WEATHER	IR	CAPACITY
12-1 (DV*:A,D)	VMC/MMC	all	1-1(A1) + 1-2(D2)
	IMC	0	2-20(C:A,D)
		>0	1-1(A1) + 1-2(D2)
12-2 (DV:B,D)	VMC	0	2-23(C:B,D)
		>0	1-3(B1) + [illegible](D2)
	MMC/IMC	0	2-20(C:A,D)
		0	1-3(B1) + 1-2(D2)
12-3 (CV*:D,A)	VMC/MMC	all	1-2(D1) + 1-1(A2)
	IMC	0	2-20(C:A2,D1)
		1,2	1-2(D1) + 1-1(A2)
		3	6-2(A2,D1)
12-4 (CV:B,A)	all	all	5-5(CV:B,A)

*DV - diverging
CV - converging

TABLE 2-2 (Cont.)

MODEL	WEATHER	IR	CAPACITY
THREE RUNWAYS INTERSECTING BEYOND			
13-1 (DV*:B,A,D)	all	all	10-1(DV:B,A,D)
13-2 (DV:B,B,D)	all	all	10-2(DV:B,B,D)
13-3 (CV*:B,D,A)	all	all	10-3(CV:B,D,A)
13-4 (CV:B,B,A)	all	all	10-4(CV:B,B,A)
FOUR RUNWAYS INTERSECTING BEYOND			
14-1 (DV*:A,A,D,D)	all	all	11-1(DV:A,A,D,D)
14-2 (DV:B,B,D,D)	all	all	11-2(DV:B,B,D,D)
14-3 (CV*:A,A,D,D)	VMC/MMC	all	11-3(CV:A,A,D,D)
	IMC	all	6-2(A1,D3)
14-4 (CV:B,B,D,D)	all	all	11-3(CV:A,A,D,D)
FOUR INTERSECTING RUNWAYS			
15-1 (A,A,D,D)	VMC		2* [6-2(A2,D3) with altered inputs]
	MMC/IMC		6-2(A2,D3) with altered inputs
15-2 (B,B,D,D)	VMC		max [2* [6-2(A2,D3) with altered inputs], 2-24(C:B,B)]
	MMC/IMC		max [2-20(C:A,D), 6-2(A1,D4)]

*DV - diverging

CV - converging

means that the configuration cannot be simplified any further, and capacity is computed as described in Section 2.2.

2.7.2 Estimation of Runway Occupancy Times

If data on average arrival runway occupancy times is not readily available, it is possible to utilize Tables 2-3 and 2-4 to derive estimates of the actual values. Table 2-3 contains typical runway occupancy times, by aircraft class, for exits located at the specified distance down the runway. In Table 2-4, the cumulative probabilities of aircraft exiting by that point are given.

To use these tables, the average time associated with each exit is multiplied by the probability of using that exit, and the results are summed together to obtain the overall value for each aircraft class.

To illustrate, we will calculate the estimated occupancy time for a type C aircraft on a 9000 foot-long runway, with regular exits located 4000 ft and 6500 ft down the runway.

From Table 2-3 the exit times for these exits are 38s (at 4000 ft), 60s (6500 ft -- interpolating between the 6000 ft and 7000 ft values), and 82s (9000 ft -- the runway end).

Table 2-4 shows the cumulative probability of exiting by the specified distance. The probability of using a specific exit will be the difference between the cumulative probability for that exit and the cumulative probability for the previous exit. In the example, the probability of using the 4000 ft exit is 0.08, of the 6500 ft exit is 0.88 (0.96-0.08), and 0.04 for the runway end (1.00-0.96). The average occupancy time for the runway is therefore 59s (= 38 * 0.08 + 60 * 0.88 + 82 * 0.04).

2.8 Examples

The following examples illustrate the use of the FAA Airfield Capacity Model.

2.8.1 Example 1 -- Single Runway, General Aviation

Compute the saturation hourly capacity of a single runway general aviation airport for 30%, 50%, and 70% arrivals in VMC. The aircraft mix consists of 85%A and 15%B aircraft. There are no touch-and-go operations. Assume typical values for all other parameters; arrival-arrival and departure-departure separations are taken from FAA-EM-78-8A.

TABLE 2-3

ESTIMATED ARRIVAL RUNWAY OCCUPANCY TIME (Seconds)

DISTANCE THRESHOLD TO EXIT (000 ft)	WET RUNWAYS				DRY RUNWAYS REGULAR EXITS				DRY RUNWAYS HIGH-SPEED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0	24	--	--	--	24	--	--	--	19	--	--	--
1	24	--	--	--	24	27	--	--	27	24	--	--
2	34	27	--	--	34	27	--	--	35	24	--	--
3	44	37	30	--	44	37	29	--	43	32	35	35
4	55	47	38	--	55	46	38	38	43	41	35	35
5	65	56	47	47	65	56	47	47	43	49	44	44
6	76	65	56	56	76	65	56	56	43	49	54	54
7	99	99	65	65	76	75	65	65	43	49	63	63
8	99	99	73	73	76	75	73	73	43	49	63	63
9	99	99	82	82	76	75	82	82	43	49	63	63
10	99	99	82	82	76	75	85	85	43	49	63	63
11	99	99	82	82	76	75	90	90	43	49	63	63

TABLE 2-4

CUMULATIVE PROBABILITY OF EXIT USAGE

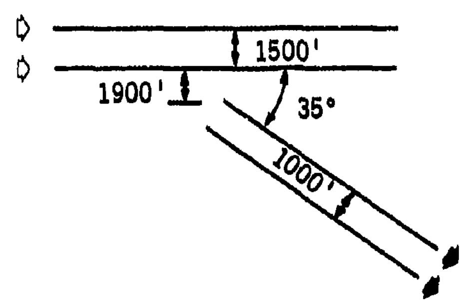
DISTANCE THRESHOLD TO EXIT (000 ft)	WET RUNWAYS				DRY RUNWAYS							
					REGULAR EXITS				HIGH-SPEED EXITS			
	A	B	C	D	A	B	C	D	A	B	C	D
0	0	0	0	0	0	0	0	0	0	0	0	0
1	4	0	0	0	6	0	0	0	13	0	0	0
2	60	0	0	0	84	1	0	0	90	1	0	0
3	96	10	0	0	100	39	0	0	100	40	0	0
4	100	80	1	0	100	98	8	0	100	98	26	3
5	100	100	12	0	100	100	49	9	100	100	75	55
6	100	100	48	10	100	100	92	71	100	100	98	95
7	100	100	88	64	100	100	100	98	100	100	100	100
8	100	100	100	93	100	100	100	100	100	100	100	100
9	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100	100	100

From Table 2-2 the runway use configuration is identified as Model 1-3(B). Figure 2-3 shows the input file for this example and the computer output.

The output indicates an arrival-priority capacity of 31.7 arrivals and 57.2 departures per hour and a departure-priority capacity of 102.9 departures. No intermediate points were specified. To obtain 30% arrivals, the program interpolates between these two points and obtains a total capacity of 90.8 operations per hour. At 50% and 70% arrivals, the arrival-priority mode provides more than enough departures; the excess are dropped.

2.8.2 Example 2 -- Four Runways, MMC

Compute the saturation hourly capacity of the runway configuration shown below, in MMC (Marginal Meteorological Conditions), for 50% arrivals. The aircraft mix consists of 3%A, 7%B, 70%C, and 20%D aircraft. There are no touch-and-go operations. Standard exits are located at 1500', 3000', 4000', 5500', 7000', and 10000' from the threshold for both runways 1 and 2. Assume typical values for all other parameters.



The computer input file for this case is shown in Figure 2-4. If average runway occupancy times are not shown, approximate values can be estimated or Tables 2-3 and 2-4 can be used, as explained in Section 2.7.2. From these tables, the following values are taken:

EXIT	TIME				PROBABILITY			
	A	B	C	D	A	B	C	D
1500'	29	--	--	--	.45	0	0	0
3000'	44	37	--	--	.55	.39	0	0
4000'	--	46	38	--	--	.59	.08	0
5500'	--	60	51	51	--	.02	.62	.40
7000'	--	--	65	65	--	--	.30	.58
10000'	--	--	--	85	--	--	--	.02

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0        *                GA AIRPORT
   1    3    0
RUNWAY 1 1 0
0.850.150.0 0.0
ARRAR2 1 2 0
 32. 40. 51. 58.
DLTAIJ 0 4 0
 1.9 1.9 1.9 1.9 1.9 1.9 1.9 1.9 2.7 2.7 1.9 1.9 4.5 4.5 3.6 2.7
APPSPD 0 5 0
  80 100 130 140
DRBAR  0 6 0
  24   29   39   39
TD      0 7 0
  35   35   45   50   35   35   45   50   50   50   60   60  120  120  120   90
GAMA    0 8 0
   1    1    6    6
TGRBAR 0 9 0
 23. 22. 27. 27.
SIGMAS 019 0
  8. 18.  0.   7.   6.
OTHERS 020 1
0.050.05 0.0 5.03500 3.00.0    30   50

SINGLE RUNWAY MIXED OPERATIONS WITHOUT T & G

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   88.85  ARRIVALS =  31.66     DEPARTURES =  57.19

    DEPARTURE PRIORITY CAPACITY
              TOTAL =  102.86  ARRIVALS =   0.0      DEPARTURES = 102.86

TO OBTAIN  30 PERCENT ARRIVALS, OPERATE
          AT POINT   1 FOR  86 PERCENT OF THE HOUR, AND
          AT DEPARTURE PRIORITY POINT FOR  14 PERCENT

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    90.8  ARRIVALS =   27.2  DEPARTURES =   63.6

        *****      *****      *****      *****      *****      *****

TO OBTAIN  50 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  25.5  OPERATIONS PER HOUR

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    63.3  ARRIVALS =   31.7  DEPARTURES =   31.7

        *****      *****      *****      *****      *****      *****
```

FIGURE 2-3
EXAMPLE 1 — INPUT/OUTPUT

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0        **     EXAMPLE 2
  14   1   0
RUNWAY 1 1 0
0.030.070.700.20
RUNWAY 2 1 0
0.030.070.700.20
RUNWAY 3 1 0
0.030.070.700.20
RUNWAY 4 1 0
0.030.070.700.20
ARBAR2 1 2 0
 37. 43. 54. 60.
ARBAR2 2 2 0
 37. 43. 54. 60.
DLTAIJ 0 4 0
 3.0 3.0 3.0 3.0 3.0 3.0 3.0 3.0 4.0 4.0 3.0 3.0 6.0 6.0 5.0 4.0
APPSPD 0 5 0
  95 120 130 140
DRBAR  0 6 0
  29   34   39   39
TD      0 7 0
  60   60   60   60   60   60   60   60   60   60   60   60 120 120 120   90
GAMA    0 8 0
   6    6    6    6
TURBAR 0 9 0
 23.  22.  27.  27.
OPENVX 010 0
  351900 0.0 0.0
SIGMAB 019 0
  8.  18.   0.   0.   6.
OTHERS 020 1
0.050.05 2.0 2.5 800 3.00.0    50

FOUR INTER BEYOND, AWAY, ARR ON #1, #2, DEP ON #3, #4

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
               TOTAL =   78.45  ARRIVALS =  27.60     DEPARTURES =  50.85

TO OBTAIN  50 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  23.2  OPERATIONS PER HOUR

               ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

               TOTAL =    55.2  ARRIVALS =   27.6  DEPARTURES =   27.6

        *****     *****     *****     *****     *****     *****
```

FIGURE 2-4
EXAMPLE 2 — INPUT/OUTPUT

The resulting average runway occupancy times are 37, 43, 54, and 60 seconds for types A, B, C, and D, respectively.

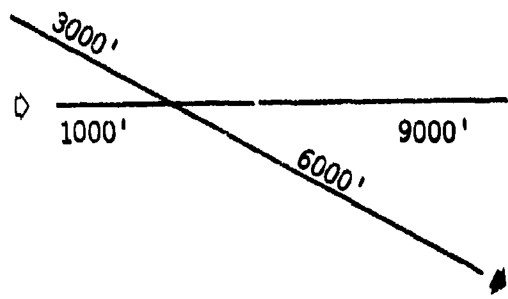
From Table 2-2, the runway use configuration is identified as Model 14-1 (DV:A,A,D,D) -- four runways intersecting beyond the threshold, diverging. Note in the input file that the aircraft mix must be entered for each runway, but the arrival occupancy times only for the arrival runways and the departure occupancy times are entered only once.

For this configuration (and for all open-V and "intersecting beyond the threshold" configurations) it was also necessary to input an OPENV line, containing the angle between runways and the distance between the non-parallel thresholds.

At 50% arrivals the capacity is 27.6 arrivals per hour and 27.6 departures. Actually, 50.9 departures are possible, but the excess are not needed.

2.8.3. Example 3 -- Intersecting Ruways, Different Aircraft Mixes

Compute the hourly capacity of the intersecting runway configuration shown below for 50% arrivals in IMC.



Compute capacity first for a mix of 60%C and 40%D aircraft, and then for a 75%C/25%D mix. Assume a future environment, according to FAA-EM-78-8A: 2.0 nmi basic arrival-arrival separation (2.5 nmi for a C following a D) and 60s between all departures. Assume typical values for all other parameters.

The runway configuration is Model 6-2 (A,D). The input file (Figure 2-5) contains all the information needed to compute capacity with both aircraft mixes: the capacity at 60%C/40%D is calculated first, and the results printed out (89.9 operations per hour), then the new mix is read in and the new capacity computed (90.6 operations).

```
** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

NEWRUN 0 0 0
   6   2   0
RUNWAY 1 1 0
0.0 0.0 0.600.40
RUNWAY 2 1 0
0.0 0.0 0.600.40
ARRAR2 1 2 0
 34. 34. 42. 45.
DLTAIJ 0 4 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.5 2.5 2.0 2.0 3.0 3.0 2.5 2.0
APPSPD 0 5 0
 95 120 130 140
DRBAR  0 6 0
 29  34  39  39
TD     0 7 0
 60  60  60  60  60  60  60  60  60  60  60  60  60  60  60  60
GAMA   0 8 0
  6   6   6   6
TGRBAR 0 9 0
 23. 22. 27. 27.
ADSR   112 0
 5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.  5.
DICRR  013 0
 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0 2.0
SIGMAS 019 0
 4.  8.  0.  0.  0.
OTHERS 020 0
0.050.01 2.0 0.0   0 3.00.0   50
INCIAT 026 1
   1.050   2 20.

TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   90.10  ARRIVALS =  45.81     DEPARTURES =  44.30

    DEPARTURE PRIORITY CAPACITY
              TOTAL =   60.00  ARRIVALS =   0.0      DEPARTURES =  60.00

    CAPACITY AT POINT #  2                MAX GAP STRETCH =  20. SEC
              TOTAL =   89.38  ARRIVALS =  43.17     DEPARTURES =  46.21

TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
         AT POINT   1 FOR  66 PERCENT OF THE HOUR, AND
         AT POINT   2 FOR  34 PERCENT

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    89.9  ARRIVALS =   44.9  DEPARTURES =   44.9

        *****     *****     *****     *****     *****     *****
```

FIGURE 2-5
EXAMPLE 3 — INPUT/OUTPUT

```
RUNWAY 1 1 0
0.0 0.0 0.750.25
RUNWAY 2 1 1
0.0 0.0 0.750.25

TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
             TOTAL =   90.87  ARRIVALS =  46.25     DEPARTURES =  44.61

    DEPARTURE PRIORITY CAPACITY
             TOTAL =   60.00  ARRIVALS =   0.0      DEPARTURES =  60.00

    CAPACITY AT POINT #  2                 MAX GAP STRETCH =  20. SEC
             TOTAL =   90.25  ARRIVALS =  44.13     DEPARTURES =  46.12

TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
        AT POINT   1 FOR  54 PERCENT OF THE HOUR, AND
        AT POINT   2 FOR  46 PERCENT

             ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    90.6  ARRIVALS =   45.3  DEPARTURES =   45.3

        *****     *****     *****     *****     *****     *****
```

FIGURE 2-5
EXAMPLE 3 — INPUT/OUTPUT
(Cont.)

APPENDIX B

REVISED VERSION OF CHAPTER 3, "ON-LINE AIRFIELD CAPACITY MODEL"

The following Appendix presents the revised version of Chapter 3 of Reference 1 dealing with the on-line (interactive) version of the FAA Airfield Capacity Model.

A Table of Contents for the revised Chapter 3 appears on the following pages.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 3 -- ON-LINE AIRFIELD CAPACITY MODEL

3.1 Introduction

The On-line Airfield Capacity Model is an adaptation of the general analytic capacity model for determining runway capacity described in Chapter 2. It employs an interactive (question and answer) routine between the computer and a user at a remote terminal. The responses by the user to the program's questions are used to construct a complete file of input data. The computer automatically checks the input to determine if it is in a valid format (e.g., the aircraft mix percentages must sum to 100%), and requests that new data be entered if the original data are invalid. The output of the On-line Airfield Capacity Model is a summary of user supplied inputs and the calculated hourly capacity of the runways. The input file is saved and can be used by the Batch Version of the program.

To utilize the On-line Airfield Capacity Model to determine runway capacity, it is necessary to have a remote computer terminal and telephone connections with a computer service which offers the On-line Airfield Capacity Model. It is not necessary to understand the details of computer operations or the Batch Capacity Model described in Chapter 2. Each user must establish his own user identification code with the computer service and must pay for the computer time, connect time, storage cost and any other charge associated with his use of the model. For additional details on accessing the On-line Airfield Capacity Model, contact:

Mr. Anees Adil, AEM-100
Office of Systems Engineering Management
Federal Aviation Administration
800 Independence Avenue, S. W.
Washington, D. C. 20591

3.2 Discussion of Terms Used by the On-line Airfield Capacity Model

In order that the ramifications of some of the questions asked by the interactive program will be better understood, certain terms will be explained in this section. This will help the user to supply the appropriate answer. These terms are:

- Air Traffic Control System
- Weather Conditions

- Runway Use Configuration
- Aircraft Mix.

3.2.1 Air Traffic Control System

The On-line Airfield Capacity Model can model either current or future ATC systems, by using the appropriate values for the arrival-arrival separations, departure-departure separations, and control system error. Four standard ATC systems are available:

- Present
- Near-term
- Intermediate
- Far-term.

A brief description of these systems may be found in Table 3-1, which shows the explanatory message which is available from the interactive program. Additional information may be found in FAA-EM-78-8A, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay."

If these standard ATC systems are inadequate, the user of the interactive version also has the option of directly specifying the interarrival separation (DLTAIJ) and the standard deviation of the interarrival times (SIGMAA).

3.2.2 Weather Conditions

Three different weather conditions are recognized by the interactive program. These are:

- VMC - Visual Meteorological Conditions
- MMC - Marginal Meteorological Conditions
- IMC - Instrument Meteorological Conditions.

The weather condition specified affects the separations used by the program and the ATC procedures which are assumed to be in effect.

TABLE 3-1

EXPLANATION OF ATC SYSTEM CODES

THE FOLLOWING ATC SCENARIOS REPRESENT FAA E & D PLANNING AS OF JANUARY, 1980, AS DESCRIBED IN FAA-EM-78-8A.

ATC CODE	TIME FRAME	DESCRIPTION
P	PRESENT	CURRENT ATC SYSTEM
N	NEAR-TERM	VAS, TERMINAL FLOW MANAGEMENT
I	INTERMEDIATE	WVAS, TERMINAL FLOW MANAGEMENT, REDUCED RUNWAY OCCUPANCY IN IMC
F	FAR-TERM	WVAS, ADVANCED TERMINAL FLOW MANAGEMENT FURTHER REDUCTIONS IN IMC RUNWAY OCCUPANCY

The differences between the weather conditions are summarized in Table 3-2. In VMC:

- o VFR (Visual Flight Rules) apply
- o Visual separations are assumed
- o Approaches to parallel runways are independent (except for any wake vortex effects) if the runways are separated by 700 feet or more.

MMC represents instrument conditions with some use of visual separations:

- o IFR (Instrument Flight Rules) apply
- o Approaches to parallel runways are independent only if they are separated by 4300 feet or more
- o Visual separations are used between arrivals and departures on the same or close parallel runways.

IMC represents full use of instrument procedures:

- o All IFR procedures used in MMC are in effect
- o A 2.0 nmi departure/arrival separation (DLTADA) is used for operations to a single runway or a close parallel pair (less than 2500' apart). This means that the departure cannot be released if the arrival is less than DLTADA from the threshold.

These IFR or VFR procedures are implemented in the program by changing the manner in which a particular runway use configuration is modeled. For example, mixed operations can be conducted on close parallel runways in VMC. In IMC, the program will implement the IFR restrictions on parallel arrival and departure operations by assigning all arrivals to one runway and all departures to the other. This process affects many of the runway use configurations in the model. Therefore, the user should specify the runway use configuration which most closely agrees with what can actually happen under the desired operating condition.

3.2.3 Runway Use Configuration

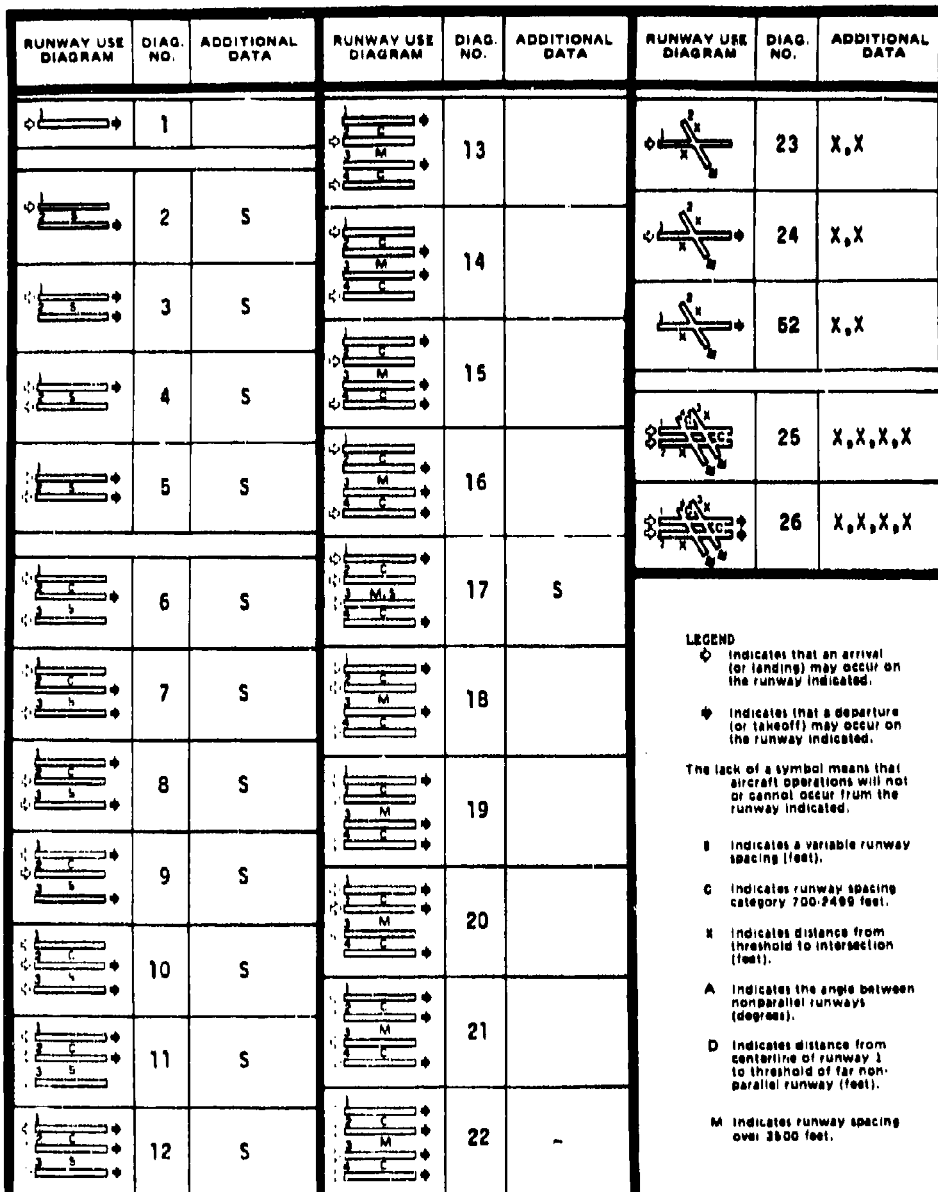
The On-line Airfield Capacity Model recognizes 52 different runway use configurations, with each runway configuration representing a unique combination of number of runways (from one to four), relative

TABLE 3-2

EXPLANATION OF WEATHER CONDITIONS

WEATHER		VISIBILITY* (STAT. MI.)	CEILING* (FEET)	OPERATIONAL IMPACT
VMC	VISUAL METEOROLOGICAL CONDITIONS	5.0	5000	VISUAL APPROACHES -- PARALLEL RUNWAYS >700' APART ARE INDEPENDENT
MMC	MARGINAL METEOROLOGICAL CONDITIONS	2.5	900	IFR SEPARATIONS APPLY BETWEEN ARRIVALS -- PARALLEL RUNWAYS <4300' APART HAVE DEPENDENT ARRIVAL OPERATIONS -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS >700' APART ARE INDEPENDENT BECAUSE VISUAL SEPARATIONS ARE APPLIED
IMC	INSTRUMENT METEOROLOGICAL CONDITIONS	0.0	0	ALL IFR PROCEDURES ARE IN EFFECT -- PARALLEL ARRIVAL AND DEPARTURE RUNWAYS <2500' APART ARE DEPENDENT

*THESE ARE VALUES WHICH ARE INPUT TO THE PROGRAM, NOT BREAKPOINTS BETWEEN WEATHER CONDITIONS



RUNWAY USE DIAGRAM	DIAG. NO.	ADDITIONAL DATA
	1	
	2	S
	3	S
	4	S
	5	S
	6	S
	7	S
	8	S
	9	S
	10	S
	11	S
	12	S
	13	
	14	
	15	
	16	
	17	S
	18	
	19	
	20	
	21	
	22	–
	23	X,X
	24	X,X
	52	X,X
	25	X,X,X,X
	26	X,X,X,X

LEGEND

- ◇ Indicates that an arrival (or landing) may occur on the runway indicated.
- ◆ Indicates that a departure (or takeoff) may occur on the runway indicated.

The lack of a symbol means that aircraft operations will not or cannot occur from the runway indicated.

- S Indicates a variable runway spacing (feet).
- C Indicates runway spacing category 700-2499 feet.
- X Indicates distance from threshold to intersection (feet).
- A Indicates the angle between nonparallel runways (degrees).
- D Indicates distance from centerline of runway 1 to threshold of far non-parallel runway (feet).
- M Indicates runway spacing over 3500 feet.

FIGURE 3-1
DIAGRAMS OF RUNWAY USE CONFIGURATIONS FOR ON-LINE CAPACITY MODEL

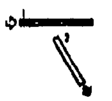
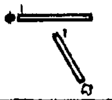
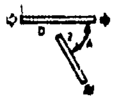
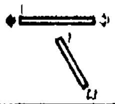
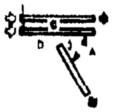
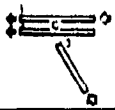
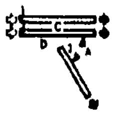
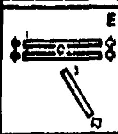
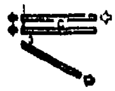
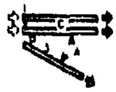
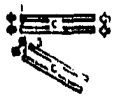
RUNWAY USE DIAGRAM	DIAG NO.	ADDITIONAL DATA
	27	S
	28	S
	29	
	30	
	31	D,A
	32	
	33	D,A
	34	
	35	D,A
	36	
	37	
	38	
	39	D,A
	40	
	41	
	42	D,A
	43	
	44	D,A
	45	
	46	D,A
	47	
	48	
	49	
	50	D,A
	51	

FIGURE 3-1
DIAGRAMS OF RUNWAY USE CONFIGURATIONS FOR ON-LINE CAPACITY MODEL
(Cont.)

position, and use for arrivals, departures, or both. Figure 3-1 pictures the 52 configurations, along with the identifying number for each and the additional information required for some configurations. These additional data include the separation distance between parallel runways, the distance from threshold to intersection, the distance between the centerline of runway number one and the threshold of the far nonparallel runway, and the angle between nonparallel runways. All distances are in feet and the angle is in degrees.

If a particular runway use configuration is not included in Figure 3-1, it may be possible to divide the runway configuration into independent components. If a very small percent of the total arrivals or departures is expected to occur on a given runway, it may be realistic to omit it in the specification of runway configuration. These methods will often permit the runway configuration to be found in Figure 3-1.

A number of assumptions have been made in developing the runway use configurations in Figure 3-1:

- For all three runway configurations except intersecting, runways 1 and 2 are assumed to be close-spaced parallel (700 to 2500 feet apart). For three parallel runways, the separation between the outer pair is assumed to be related to the user-specified separation between runways 2 and 3 as follows:

S	C + S
700-2499 ft (close)	2500-4299 ft (medium)
2500-3499 ft (near)	3500-4299 ft (medium)
3500-4299 ft (medium)	4300 ft or more (far)
4300 ft or more (far)	4300 ft or more (far)

where S is the user-input separation between runways 2 and 3,

C + S is the separation between runways 1 and 3.

Note that there is no difference in the operating characteristics of near- or medium-spaced runways -- the distinction is made here only to determine the spacing of the outer pair.

- For three intersecting runways, no operations occur on the crossing runway. The user should consider specifying one of the two parallel runway configurations instead.

- For four runway configurations, runways 1 and 2 and runways 3 and 4 are assumed to be close-spaced parallels. The separation between the inner parallel pair, 2 and 3, is assumed to be 2500 feet or greater.

3.2.4 Aircraft Mix

In general, unless there are specific constraints on certain aircraft types, it is advisable to use the same aircraft mix on each runway. This mix would represent the aircraft which use the airport over the course of an entire day.

If different mixes are used on each runway, the overall airport mix may not be preserved, and airport capacity may be overestimated. For example, a general aviation runway may be able to handle many more general aviation aircraft than are present. GA capacity may be greater than GA demand, but air carrier capacity may still be inadequate. To minimize the chance of misinterpreting the model results in some cases, independent runways should be analyzed separately, and demand/capacity comparisons should be made for each aircraft type separately.

If the demand of a particular aircraft type is greater than its capacity, it may be possible to adjust the mix on each runway to increase capacity. In general, a more homogeneous mix will produce a higher capacity.

3.3 Data Input

In this section, each question which may be asked by the interactive program will be presented and explained. Both long and short forms will be given. Table 3-3 summarizes the questions, expected answers, and possible error messages.

3.3.1 General Information

The following general points apply:

- Not all these questions will be asked in any single run because several questions are applicable only to certain runway configurations.

- Multiple input items may be separated by one or more blanks or a comma.

- Entering the wrong number of items will produce an error message and the question will be presented again.

TABLE 3-3

ON-LINE VERSION INPUT AND ERROR MESSAGES

DATA REQUEST	SHORT FORM	APPLICABILITY	VALID INPUT	MESSAGE FOR INVALID DATA
DO YOU WANT AN EXPLANATION OF ATC SYSTEM CODES?	None	After accessing computer	1 to 3 yes or no answers	Any response other than "N" or "NO" is treated as a yes reply
ENTER ATC SYSTEM CODE (P / N / I / F)	ATC CODE	Always used	P, N, I, F, PX, NX, IX, or FX	ERR INCORRECT ATC SYSTEM
ENTER VMC, MMC (MARGINAL IMC), OR IMC	WEATHER	Always used	V, M or I	ERR WEATHER MUST BE VMC, IMC, OR MMC
ENTER LENGTH OF FINAL APPROACH (CLASS A B C D)- 4 VALUES	FINAL APPROACH (A B C D)	VMC only	Four integers	No special error message (see GENERAL ERROR MESSAGES)
ENTER LENGTH OF FINAL APPROACH, ALL CLASSES - 1 VALUE	FINAL APPROACH, ALL	MMC and IMC	One integer	No specific error message
ENTER RUNWAY USE DIAGRAM NUMBER (1-52)	R/W #	Always used	Integer 1 through 52	ERR RUNWAY USE DIAGRAM NUMBER MUST BE BETWEEN 1 & 52
ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D) FOR EACH PRINTED RUNWAY NUMBER 1- 2- 3- 4-	R/W MIX	For all runways in the runway use diagram	Four integers which sum to 100. If fifth entry is 'ALL' same mix will be used for all runways.	5TH PARAMETER IS NOT ACCEPTABLE UNLESS IT IS 'ALL', REENTER ERR MIX PERCENTAGE DOES NOT TOTAL 100 FOR RUNWAY #___ REENTER
ENTER APPROACH SPEEDS	SPEEDS	Always used	Four integers	No special error message
ENTER SEPARATION 'S' BETWEEN PARALLEL RUNWAYS (FEET)	SEPARATION S	Parallel runways	Integer less than 10000	No special error message
RUN ALTERNATING APPROACHES?	ALTERNATING?	Parallel runways, MMC or IMC, separation ≥3000 ft	yes or no reply	No special error message
ENTER DIAGONAL SEPARATION (NMI), AND EXTRA DISTANCE FLOWN TO RW2 (FT)	DIAG SEP & DIST TO RW 2	Parallel runways with alternating arrivals	Two integers	No special error message
ENTER DISTANCE 'X' BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET) 1- 2- 3- 4-	THRESHOLD TO INTERSECTION X	Intersecting runways (models 23 through 26, plus 52), for each runway	Integer under 10000	ERR THRESHOLD TO INTERSECTION DISTANCE MUST BE AN INTEGER BETWEEN 0 & 9999
ARE AIRCRAFT AIRBORNE AT INTERSECTION?	AIRBORNE INTER?	Intersecting runways	yes or no reply	No special error message
ENTER DISTANCE 'D' BETWEEN THE THRESHOLD RW1 AND FARTHEST RUNWAY (FEET)	THRESHOLD RW1 TO FARTHEST RW 'D'	R/w use diagram 31, 33, 35, 39, 42, 44, 46, 50	Integer	No special error message

TABLE 3-3

ON-LINE VERSION INPUT AND ERROR MESSAGES
(Cont.)

DATA REQUEST	SHORT FORM	APPLICABILITY	VALID INPUT	MESSAGE FOR INVALID DATA
ENTER ANGLE 'A' BETWEEN NONPARALLEL RUNWAYS (DEGREES)	ANGLE A	R/w use diagram 31, 33, 35, 39, 42, 44, 46, 50	Integer from 1 to 90	ERR ANGLE MUST BE AN INTEGER BETWEEN 1 & 91
ENTER DLTAIJ (3, 5, OR 16 VALUES)	DLTAIJ	If 'X' suffix is added to ATC system code	3, 5 or 16 numbers. Need not be integers.	ERR INPUT CAN BE 3, 5, or 16 NUMBERS, ____ WERE INPUT
ENTER INTERARRIVAL SIGMA	SIGMAA	If 'X' suffix is added to ATC system code	One number, need not be integer	No special error message
ENTER ARRIVAL PERCENTAGE (UP TO 11 VALUES)	ARRIVAL %	Always used	Up to 11 integers ≤ 100. First value may be 9999, 8888, or 7777.	ERR PERCENTAGE MUST BE AN INTEGER BETWEEN 1 & 100 NO. ___ WAS INCORRECT
ENTER TOUCH & GO PERCENTAGE	T&G %	VMC, r/w use diagram 1-5	Integer less than twice arrival percentage or twice departure percentage	ERR PERCENTAGE MUST BE AN INTEGER BETWEEN 1 & ____
ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH PRINTED RUNWAY NUMBER 1- 2- 3- 4-	EXIT TIMES	Always used. Number of runways based on r/w use diagram.	Four integers	EXIT TIME IS MINIMUM OF USER INPUT AND MAX VALUES: ________ (warning message, for I or F ATC systems. Max values are in FAA-EM-78-8A.)

GENERAL ERROR MESSAGES -- apply to all data requests

INVALID INPUT	COMPUTER RESPONSE
Blank input	WHAT ? ?
Too few inputs	Data request is repeated
Too many inputs	ERR A MAXIMUM OF ___ PARAMETERS ARE ALLOWED IN THIS QUESTION. . . ___ WERE INPUT
More than 16 inputs on a line	WHAT ? ?
Floating-point when integer is required	Data request is repeated
Character data (including negative sign) when integer is required	ERR I AM EXPECTING A NUMBER, NOT A LETTER OR WORD
Character data longer than 6 letters	ERR (___) ILLEGAL ANSWER OR NUMBER REENTER
HALT	RESTARTING PROGRAM. . . . DO YOU WISH TO PERFORM ANOTHER CALCULATION?

- o Execution may be halted at any time by entering 'HALT'. The user then may start over, or cancel the job.

- o The program assumes four aircraft classes (A, B, C, and D), with A being small aircraft (under 12,500 pounds), B and C being large aircraft (12,500 to 300,000 pounds), and D being heavies (over 300,000 pounds). All pertinent inputs are to be in this order.

3.3.2 Specific Questions

- DO YOU WANT AN EXPLANATION OF A T C SYSTEM CODES?

A YES or Y answer will print the message in Table 3-1, briefly describing the four standard ATC scenarios.

Two additional YES/NO answers are optional on this line. The first of these deals with question length; if this is NO (or N), the short form of the question will be printed. A final NO on this line will cancel the input summary usually printed after all the questions have been asked.

- ENTER ATC SYSTEM CODE (P / N / I / F)
- ATC CODE

Entry of one of the four code letters will result in standard values being used for arrival and departure separations, M&S performance, etc. The standard values are taken from FAA-EM-78-8A. The user may also input non-standard values for the arrival separation (DLTAIJ) and for the sigma of the interarrival time (SIGMAA). To do this, the user would add an 'X' to the ATC code otherwise chosen. For example, an entry of 'PX' would result in present-day values being used for departure separations and probabilities of violation, but DLTAIJ and SIGMAA would be user inputs, as described later.

- ENTER VMC, MMC (MARGINAL IMC), OR IMC
- WEATHER

One of three weather conditions is to be entered here. It is sufficient to enter just the first letter ('V,' 'M,' or 'I'). The ceilings and visibilities associated with each condition, and the effect of each condition on airport operation, are given in Table 3-2.

- ENTER LENGTH OF FINAL APPROACH, (CLASS A B C D) -- FOUR VALUES
- FINAL APPROACH (A B C D)

This message is printed only if VMC has been specified. Four numbers are to be entered, representing the final approach path length in nautical miles for each aircraft class.

- ENTER LENGTH OF FINAL APPROACH, ALL CLASSES -- ONE VALUE
- FINAL APPROACH, ALL

In MMC and IMC, all aircraft are assumed to fly the same final approach path. Consequently, only one number needs to be input in this response.

- ENTER RUNWAY USE DIAGRAM NUMBER (1-52)
- R/W #

The runway diagram number is obtained from Figure 3-1.

- ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
  FOR EACH PRINTED RUNWAY NUMBER
- R/W MIX

Four numbers, for the percentage of each aircraft class in the fleet mix, are to be entered in response to the runway number. Again, the model assumes a small/large/large/heavy mix. For multi-runway configurations, typing the word 'ALL' after the four percentages will result in the same fleet mix being used for all runways.

- ENTER APPROACH SPEEDS
- SPEEDS

The approach speeds for the four aircraft classes, in knots, are entered here. This speed is assumed to be constant from the start of the final approach path to the runway threshold. An average speed for this segment may be used.

- ENTER SEPARATION 'S' BETWEEN PARALLEL RUNWAYS
- SEPARATION S

For parallel runway configurations only, the distance in feet between the centerlines of runways 2 and 3 is requested. For three and four parallel runways, one or two runway pairs are assumed to be close spaced (700-2499 feet).

- RUN ALTERNATING APPROACHES?
- ALTERNATING?

In MMC, this question will be asked if the runway separation is large enough to allow alternating approaches. A 'Y' or 'N' answer is required.

- ENTER DIAGONAL SEPARATION (NMI), AND EXTRA DISTANCE FLOWN TO RW2 (FT)
- DIAG SEP & DIST TO RW2

The diagonal separation standard (2.0 nmi today) is the minimum spacing applied between alternating arrivals on parallel runways. The "extra distance flown" is a measure of the runway threshold displacement; a negative value would be entered if the runway 2 threshold were closer.

This question is only presented if a 'YES' answer was given to the previous question.

- ENTER DISTANCE 'X' BETWEEN THRESHOLD AND INTERSECTION FOR EACH PRINTED RUNWAY NUMBER (FEET)
- THRESHOLD TO INTERSECTION X

For intersecting runways only, the distance to the intersection is requested. This information is used to compute the times required for departures and arrivals to clear the intersection, which then determines ADSR and DICBR, the arrival-departure and departure-arrival separations.

- ARE AIRCRAFT AIRBORNE AT INTERSECTION?
- AIRBORNE INTER?

A 'Y' or 'N' answer is all that is needed for this question, asked only for intersecting configurations. The answer is used to determine whether to apply vortex separations at the intersection.

- ENTER DISTANCE 'D' BETWEEN THE THRESHOLD RW1
  AND FARTHEST RUNWAY (FEET)
- THRESHOLD RW1 TO FARTHEST RW 'D'

Asked for open-V and "intersecting beyond the threshold" configurations. The distance D is indicated on the diagrams in Figure 3-2.

- ENTER ANGLE 'A' BETWEEN NONPARALLEL RUNWAYS (DEGREES)
- ANGLE A

This question is similar to the previous one. The answers to these two questions are used to determine the degree of dependence between operations on the two runways.

- ENTER DLTAIJ (3, 5, OR 16 VALUES)
- DLTAIJ

If the user specified 'X' as part of the ATC code, this question and the next will be asked. For the arrival separation DLTAIJ, the user can enter 3, 5, or 16 numbers. Figure 3-2 shows how these values are arranged into the 4 X 4 separation matrix.

- ENTER INTERARRIVAL SIGMA
- SIGMAA

The value requested is the standard deviation of the interarrival time at the threshold, in seconds.

- ENTER ARRIVAL PERCENTAGE (UP TO 11 VALUES)
- ARRIVAL %

The percentage of arrivals in the total operations count is a required input. Up to 11 values can be entered. This limit was chosen to accommodate the case of zero to 100% by 10% increments.

The first value to be input could also be one of three special values: 9999, 8888, or 7777. These special values are explained in Chapter 2. If they appear elsewhere than in the first position, an error message will be returned.

o 3 NUMBER INPUT (1-3)

LEAD \ TRAIL	A	B	C	D
A	1	1	1	1
B	1	1	1	1
C	1	1	1	1
D	3	3	3	2

o 5 NUMBER INPUT (1-5)

LEAD \ TRAIL	A	B	C	D
A	1	1	1	1
B	4	1	1	1
C	4	1	1	1
D	5	3	3	2

o 16 NUMBER INPUT (1-16)

LEAD \ TRAIL	A	B	C	D
A	1	2	3	4
B	5	6	7	8
C	9	10	11	12
D	13	14	15	16

FIGURE 3-2
EXPANSION OF DLTAIJ MATRIX

- ENTER TOUCH & GO PERCENTAGE
- T & G %

If the weather is VMC, and the configuration is single, parallel, or open V, this question is asked. The value entered must be less than twice the first arrival percentage entered above, and less than twice the corresponding departure percentage.

- ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH PRINTED RUNWAY NUMBER
- EXIT TIMES

For all configurations, this question is asked. Four values are entered, one for each aircraft class. For immediate and far-term ATC, certain maximum values of occupancy time have been specified in FAA-EM-78-8A. If either the 'I' or 'F' code has been specified for ATC, the program will use the minimum of the user-specified values and these stored maximum values, and print a warning message to the user.

After these questions have been asked, a summary of the input items will be printed, unless the no-summary option was chosen. Capacity is then calculated.

The program next asks, 'DO YOU WISH TO PERFORM ANOTHER CALCULATION?'. If the answer is 'Y,' the interactive questions will be repeated, starting with 'ENTER ATC SYSTEM CODE.'

3.4 Output

The input data summary printed by the program includes the ATC system, weather, runway use diagram, and aircraft mix and type of operation for each runway. Other information may be contained as well, depending upon the configuration. This input summary is printed unless the program is instructed not to; it can serve as a permanent record of the inputs used for the calculation.

After this summary, a one-line description of the runway configuration is printed, followed by the capacity results. First printed is the arrival-priority capacity: the maximum number of arrivals possible, plus the number of departures which can be inserted between arrivals without disrupting the flow. This may be followed by the departure-priority capacity (the maximum number of departures, plus any arrivals to non-interferring runways) and the intermediate capacities, if these are required for the calculation.

The intermediate capacities represent cases where the gap between arrivals is "stretched" by a small increment in order to accommodate more departures.

The arrival and departure capacities at the specified arrival percentage(s) are then printed, along with a description of the means by which the particular percentage was attained: elimination of excess arrivals or departures, or by a specified mix of operating strategies.

After the capacity is printed out, the program asks 'DO YOU WISH TO PERFORM ANOTHER CALCULATION?' Any answer other than 'Y' or 'YES' will end the run.

The On-line Airfield Capacity Model prepares an input data file for each run which is then submitted to the Batch version of the program discussed in Chapter 2. The input file for the last (or only) case in each run is automatically saved and may be used for additional runs. For more details, see Section 2. An example of such an input file may be found in Section 3.6.4 where it can be compared with the terminal input which created it.

3.5 Sensitivity Analysis

The FAA Airfield Capacity Model has been designed to facilitate sensitivity analyses of runway configurations. Often such analyses take the form of determining the effect on capacity of varying the percentage of arrivals. It is possible to specify up to 11 different arrival percentages for a single run of the interactive version; the order in which these are specified is not important. For an example, see Section 3.6.4.

Other sensitivity analyses may involve varying the aircraft mix, the runway occupancy times, and so on. To vary these parameters, the user has two options:

- Use the interactive version a multiple number of times, once for each variation, or

- Use the interactive version once, for the basic case, and then modify the resulting batch input file. Several cases can be evaluated with each run of the batch version simply by appending the data for the items which vary to the end of the basic input file. For more information, refer to Section 2.4.

3.6 Examples

3.6.1 Example 1 -- Single Runway, IMC

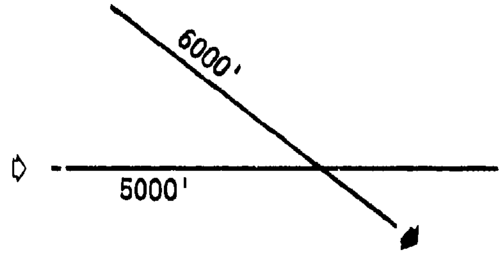
Determine the arrival-priority capacity of a single runway in IMC.

Aircraft Mix:	0%A, 5%B, 75%C, 20%D
Percent Arrivals:	9999 (arrival-priority)
Percent Touch-And-Go:	0
Runway Occupancy Times:	35, 42, 46, 51 seconds

Other inputs are standard. From Figure 3-1, runway configuration 1 is selected. The terminal session is shown in Figure 3-3. The computer output is in upper case, user input is lower case. Note the use of blanks and commas to separate input items, the input summary, and the form of the capacity output.

3.6.2 Example 2 -- Intersecting Runways, VMC

Determine the hourly capacity of the runway configuration shown below, in VMC, assuming a 1:1 ratio of arrivals to departures.



Aircraft Mix:	0%A, 5%B, 50%C, 45%D
Percent Arrivals:	50%
Percent Touch-And-Go:	0
Runway Occupancy:	30, 35, 40, 45 seconds

Arrival-Arrival Separations:

DLTAIJ:	2	2	2	2
	2	2	2	2
	2	2	2	2
	2	2	2	2

```
        ** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

              *** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
no

ENTER ATC SYSTEM CODE ( P / N / I / F )
p

ENTER VMC, MMC (MARGINAL IMC), OR IMC
i

ENTER LENGTH OF FINAL APPROACH, ALL CLASSES
6

ENTER RUNWAY USE DIAGRAM NUMBER (1 - 52)
1

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
FOR EACH PRINTED RUNWAY NUMBER
1-
0 5 75 20

ENTER APPROACH SPEEDS
95 120 130 140

ENTER ARRIVAL PERCENTAGE ( UP TO 11 VALUES)
9999

ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH
PRINTED RUNWAY NUMBER
1-
35,42, 46, 51

          *** INPUT SUMMARY ***

          PRESENT  ATC SYSTEM
          IMC  WEATHER
          RUNWAY USE DIAGRAM =    1
          PERCENT TOUCH + GO =    0
          PERCENT  ARRIVALS  =  9999

R/W    AIRCRAFT    MIX     TYPE
 #     (A)  (B)  (C)  (D)   OPN

 1      0.   5.  75.  20.   BOTH



SINGLE RUNWAY MIXED OPERATIONS WITHOUT T & G

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
              TOTAL =   54.58  ARRIVALS =  28.95    DEPARTURES =  25.63

DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
no
```

FIGURE 3-3
EXAMPLE 1 — TERMINAL INPUT/OUTPUT

Sigma: 8 seconds

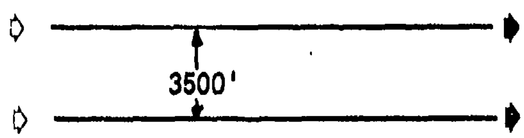
Approach Speeds: 95, 120, 130, 140 kn.

General aviation aircraft conduct short approaches (i.e., 2 nmi), all others use 6 nmi. From Figure 3-1, it is found that runway configuration 23 is appropriate.

Figure 3-4 shows the terminal dialogue. Note that an error was made on the final approach path lengths; the program was halted, and started over, to enter the proper values. Note also the error in the input aircraft mix and the resulting error message, also the user input of non-standard values.

3.6.3 Example 3 -- Parallel Runways, Alternating Arrivals

Determine the hourly capacity of the runway use shown below, in IMC, with 2.0 nmi diagonal separation between alternating arrivals.



Aircraft Mix: 0%A, 0%B, 50%C, 50%D

Percent Touch-And-Go: 0

Percent Arrivals: 60%

Runway Occupancy Times: 45, 48, 55, 63 seconds (Runway 1)
42, 47, 53, 60 seconds (Runway 2)

The runway use configuration is number 5, from Figure 3-1. In the program output (Figure 3-5), note that the input summary has been deleted, and extra input has been requested for the alternating arrival case. The capacity is 71 operations per hour.

3.6.4 Example 4 -- Parallel Runways, Sensitivity Analysis

Determine the sensitivity of hourly capacity to arrival percentage for the following case:

```
*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
n n
ATC CODE
px
WEATHER
v
FINAL APPROACH (A B C D)
2 2 6 6
R/W #
halt


RESTARTING PROGRAM
DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
yes

*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
n n
ATC CODE
px
WEATHER
v
FINAL APPROACH (A B C D)
2 6 6 6
R/W #
23
R/W MIX
1-
0 5 70 45

ERR  MIX PERCENTAGE DOES NOT TOTAL 100 FOR RUNWAY # 1
REENTER
1-
0 5 50 45
2-
0 5 50 45
SPEEDS
95 120 130 140
THRESHOLD TO INTERSECTION X
1-
5000
2-
6000
AIRBORNE INTER ?
n
DLTA1J
2 2 2
SIGMAA
8
ARRIVAL %
50
EXIT TIMES
1-
30 35 40 45
2-
30 35 40 45
```

FIGURE 3-4
EXAMPLE 2 - TERMINAL INPUT/OUTPUT

```
*** INPUT SUMMARY ***

PRESENT  ATC SYSTEM
VMC  WEATHER
RUNWAY USE DIAGRAM =  23
PERCENT TOUCH + GO =   0
PERCENT  ARRIVALS  =    50
DISTANCES BETWEEN THRESHOLDS AND INTERSECTION    5000    6000
DLTAIJ =  2.0 2.0 2.0 2.0
          2.0 2.0 2.0 2.0
          2.0 2.0 2.0 2.0
          2.0 2.0 2.0 2.0
SIGMAA =  8.00
PV     =  0.05


R/W    AIRCRAFT    MIX     TYPE
#     (A)  (B)  (C)  (D)   OPN

1      0.   5.  50.  45.   ARR
2      0.   5.  50.  45.   DEP



TWO INTERSECTING, ARR ON #1, DEP ON #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
            TOTAL =   63.25  ARRIVALS =  41.36     DEPARTURES =  21.89

    DEPARTURE PRIORITY CAPACITY
            TOTAL =   44.49  ARRIVALS =   0.0      DEPARTURES =  44.49

    CAPACITY AT POINT #  2               MAX GAP STRETCH =  20. SEC
            TOTAL =   64.30  ARRIVALS =  35.44     DEPARTURES =  28.86



TO OBTAIN  50 PERCENT ARRIVALS, OPERATE
        AT POINT   2 FOR  87 PERCENT OF THE HOUR, AND
        AT DEPARTURE PRIORITY POINT FOR  13 PERCENT

            ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

            TOTAL =    61.7  ARRIVALS =   30.9  DEPARTURES =   30.9

      *****    *****    *****    *****    *****    *****


DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
no
```

FIGURE 3-4
EXAMPLE 2 — TERMINAL INPUT/OUTPUT
(Cont.)

```
*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
no yesy no

ENTER ATC SYSTEM CODE ( P / N / I / F )
p

ENTER VMC, MMC (MARGINAL IMC), OR IMC
i

ENTER LENGTH OF FINAL APPROACH, ALL CLASSES
5

ENTER RUNWAY USE DIAGRAM NUMBER (1 - 52)
5

ENTER AIRCRAFT MIX PERCENTAGE (CLASS A B C D)
FOR EACH PRINTED RUNWAY NUMBER
1-
0,0,50,50,all

ENTER APPROACH SPEEDS
95,120,130,140

ENTER SEPARATION 'S' BETWEEN PARALLEL RUNWAYS (FEET)
3500

RUN ALTERNATING APPROACHES ?
yes

ENTER DIAGONAL SEPARATION (NMI), AND EXTRA DISTANCE FLOWN TO RW 2 (FT)
2 0

ENTER ARRIVAL PERCENTAGE ( UP TO 11 VALUES)
60

ENTER AVERAGE OCCUPANCY TIMES BY CLASS, FOR EACH
PRINTED RUNWAY NUMBER
1-
45,48,55,63
2-
42,47,53,60


*** ALTERNATING APPROACHES -- 2.0 NMI/ 3500. FT ***
TWO PARALLEL, MEDIUM, IMC, MIXED ON #1 AND #2

    ARRIVAL PRIORITY CAPACITY  (POINT #1)
            TOTAL =   95.17  ARRIVALS =  42.70     DEPARTURES =  52.47

TO OBTAIN  60 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  24.0  OPERATIONS PER HOUR

            ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

            TOTAL =    71.2  ARRIVALS =    42.7  DEPARTURES =   28.5

      *****     *****     *****     *****     *****     *****
```

FIGURE 3-5
EXAMPLE 3 — TERMINAL INPUT/OUTPUT

Runway Configuration:	2
Weather:	VMC
Aircraft Mix:	10%A, 10%B, 50%C, 30%D
Runway Separation:	1000 feet
Percent Touch-And-Go:	0
Percentage Arrivals:	0, 35, 50, 65, 100%
Runway Occupancy:	45, 53, 53, 55 seconds (Runway 1) 42, 51, 55, 58 seconds (Runway 2).

Program output is shown in Figure 3-6. The short form of questioning was used.

The sensitivity of airfield capacity is found to be:

Arrival Percentage	Hourly Capacity
0%	49
35	76
50	69
65	53
100	35

The input file created by this terminal session is presented in Figure 3-7. A comparison reveals that some items reflect the user inputs, while others are standard values. For complete control over the parameters used in the capacity calculation, the user is urged to use the Batch Version of the program (see Chapter 2).

** FAA CAPACITY MODEL - REVISED JANUARY, 1980 **

```
*** AIRFIELD HOURLY CAPACITY MODEL***

DO YOU WANT AN EXPLANATION OF  A T C  SYSTEM CODES ?
n n n
ATC CODE
p
WEATHER
v
FINAL APPROACH (A B C D)
1 1 5 5
R/W #
2
R/W MIX
1-
10 10 50 30 all
SPEEDS
100 110 130 140
SEPARATION S
1000
ARRIVAL %
0,35,50,65,100
T & G  %
0
EXIT TIMES
1-
45 53 53 55
2-
42 51 55 58


TWO PARALLEL, CLOSE, VMC, ARR ON #1, DEPT ON #2

    ARRIVAL PRIORITY CAPACITY   (POINT #1)
              TOTAL =   83.88  ARRIVALS =  34.73    DEPARTURES =  49.15

    DEPARTURE PRIORITY CAPACITY
              TOTAL =   49.15  ARRIVALS =   0.0     DEPARTURES =  49.15

DEPARTURE PRIORITY CONFIGURATION PROVIDES DESIRED PERCENT ARRIVALS

              ***  AIRFIELD HOURLY RUNWAY CAPACITY  ***

              TOTAL =    49.1  ARRIVALS =    0.0  DEPARTURES =   49.1

         *****     *****     *****     *****     *****     *****
```

FIGURE 3-6
EXAMPLE 4 — TERMINAL INPUT/OUTPUT

```
TO OBTAIN  35 PERCENT ARRIVALS, OPERATE
        AT POINT   1 FOR  76 PERCENT OF THE HOUR, AND
        AT DEPARTURE PRIORITY POINT FOR  24 PERCENT

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    75.6  ARRIVALS =   26.5  DEPARTURES =   49.1

       *****    *****    *****    *****    *****    *****

TO OBTAIN  50 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  14.4  OPERATIONS PER HOUR

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    69.5  ARRIVALS =   34.7  DEPARTURES =   34.7

       *****    *****    *****    *****    *****    *****

TO OBTAIN  65 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  30.4  OPERATIONS PER HOUR

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    53.4  ARRIVALS =   34.7  DEPARTURES =   18.7

       *****    *****    *****    *****    *****    *****

TO OBTAIN 100 PERCENT ARRIVALS,
AVAILABLE DEPARTURE CAPACITY IS REDUCED BY  49.1  OPERATIONS PER HOUR

             *** AIRFIELD HOURLY RUNWAY CAPACITY  ***

             TOTAL =    34.7  ARRIVALS =   34.7  DEPARTURES =    0.0

       *****    *****    *****    *****    *****    *****

DO YOU WISH TO PERFORM ANOTHER CALCULATION ?
NO
```

FIGURE 3-6
EXAMPLE 4 — TERMINAL INPUT/OUTPUT
(Cont.)

```
NEWRUN    0 0
   2  20    0
RUNWAY 1 1 0
0.100.100.500.30
RUNWAY 2 1 0
0.100.100.500.30
ARBAR2 1 2 0
 45. 53. 53. 55.
ARBAR2 2 2 0
 42. 51. 55. 58.
DLTAIJ    4 0
 1.9 1.9 1.9 1.9 2.7 1.9 1.9 1.9 2.7 1.9 1.9 1.9 4.5 3.6 3.6 2.7
APPSPD    5 0
 100 110 130 140
DRBAR     6 0
  34  34  39  39
TD        7 0
  35  45  45  50  50  60  60  60  50  60  60  60 120 120 120  90
GAMA      8 0
   1   1   5   5
TGRBAR   9 0
 23. 22. 27. 27.
SIGMAS  19 0
  8. 18.  0.  0.  6.
OTHERS  20 0
0.050.05 0.0 5.05000 3.00.0    0  35  50  65 100
INCIAT  26 0
   1 .05   2 20.
BDD      22 0
  0.  0.  0. 25.  0.  0.  0. 20.  0.  0.  0. 10. 25. 20. 10.  0.
BAA      24 1
  0.  0.  0. 25.  0.  0.  0. 20.  0.  0.  0. 10. 25. 20. 10.  0.
```

FIGURE 3-7
EXAMPLE 4 — INPUT FILE

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APPENDIX C

GLOSSARY

A	-	Arrivals.
A	-	First of four classes of aircraft (ABCD), usually small.
AA	-	A class A arrival followed by a class A arrival.
AB	-	A class A arrival followed by a class B arrival.
AC	-	A class A arrival followed by a class C arrival.
AD	-	A class A arrival followed by a class D arrival.
ADSR	-	Item 12 of the input file. Contains ADSR information required for certain non-parallel configurations.
ADSR(I,J,IRUM)	-	Arrival/departure separation requirement -- for intersecting runways, the minimum time after arrival I crosses the threshold at which departure J can be released.
ADSRX	-	A single value of ADSR which applies to all values of I and J.
ALPHA	-	Space available for comments on each header line of the input file.
ALTARR	-	Item 25 of the input file, containing information needed for alternating arrival operations.
APPSPD	-	Item 5 of the input file, containing approach speeds.
ARBAR(IRUM,I)	-	The average runway occupancy time of aircraft I on runway IRUM.
ARBAR2	-	Item 2 of the input file, containing arrival runway occupancy data.
ATC	-	Air Traffic Control.

B - Second of four aircraft classes (ABCD), usually either small or large (assumed large by on-line version of the Capacity Model).

B - Both arrivals and departures on the same runway -- mixed operations.

BA - A class B arrival followed by a class A arrival.

BAA - Item 24 of the input file, containing data for close-spaced parallel approaches.

BAA(I,J) - Buffer time between consecutive arrivals to separate close-parallel runways to prevent a heavy aircraft from overtaking a slower non-heavy aircraft.

BB - A class B arrival followed by a class B arrival.

BC - A class B arrival followed by a class C arrival.

BD - A class B arrival followed by a class D arrival.

BDD - Item 22 of the input file, containing data for close-spaced parallel departures.

BDD(I,J) - Buffer time between consecutive departures on separate close-spaced parallel runways.

C - Close-spaced parallel runways (700-2499 feet apart).

C - Third of four aircraft classes (ABCD), usually large.

CA - A class C arrival followed by a class A arrival.

CB - A class C arrival followed by a class B arrival.

CC - A class C arrival followed by a class C arrival.

cc - Card column.

CD - A class C arrival followed by a class D arrival.

CDC - Control Data Corporation.

CEILNG - Weather ceiling, in feet.

CLDIST - Distance between centerlines of two parallel runways.

CNV - Convergence criterion used in f.e.d. mix calculations.

D - Last of four aircraft classes (ABCD), usually heavy.

DA - A class D arrival followed by a class A arrival.

DB - A class D arrival followed by a class B arrival.

DC - A class D arrival followed by a class C arrival.

DD - A class D arrival followed by a class D arrival.

DDSR(I,J) - Departure/departure separation requirement -- minimum time between departures I and J, in seconds.

DELIAT - The incremental time (in seconds) by which arrival gaps are stretched.

DIAGSP - The diagonal separation required between alternating arrivals on separate runways.

DICBR - Item 13 of the input file. Contains DICBR information needed for some non-parallel configurations.

DICBR(I,J) - On intersecting runways, the minimum distance arrival J can be from the threshold when departure I is released.

DICBRX - A single value of DICBR which applies to all values of I and J.

DLTADA - The minimum distance an arrival must be from the threshold in order to release a departure on the same or close-parallel runway.

DLTAIJ - Item 4 in the input file, containing interarrival separations.

DLTAIJ(I,J) - The minimum airborne separation required between lead aircraft I and trail aircraft J.

DRBAR - Item 6 in the input file, containing departure runway occupancy times.

DRBAR(I)	-	Average departure runway occupancy time for class I
DV	-	Diverging; refers to operations on non-parallel, non-intersecting runways.
F	-	Future ATC system, standard set of parameter values.
F	-	Far-spaced parallel runwrys (more than 4300 feet apart).
FAA	-	Federal Aviation Administration.
f.e.d.	-	First enqueued departure -- refers to the probability that a particular aircraft type will be the first in line to depart, as different from the overall proportion of that type in the fleet.
GA	-	General aviation.
GAMA	-	Item 9 in the input file, containing final approach path lengths.
GAMA(I)	-	The final approach path length for class I.
GSLOPE	-	Glide slope angle.
GTDISP	-	The relative displacement of the final approach gates, used for alternating arrivals.
I	-	Typically, the lead aircraft in the current arrival pair IJ.
IALT	-	Flag which indicates whether or not alternating arrivals are to be modeled.
IAX	-	Flag used to indicate whether aircraft are airborne at the runway intersection.
IFR	-	Instrument Flight Rules
IMC	-	Instrument Meteorological Conditions.
IMODEL	-	The model series of the configuration being analyzed.
INCIAT	-	Item 26 of the input file, containing data for the first-enqueued departure and gap-stretching options.

INDEX - The number of each item in the data file. Located on the header line, it informs the program what data is contained on the next line.

INST - The number of intermediate points to calculate, plus one (for arrival-priority point).

IPA - The arrival percentage(s) at which capacity is to be calculated.

IR - Flag which indicates the degree of dependence between two non-parallel, non-intersecting runways.

IRUM - The number (1-4) of the runway to which the following data pertains. Required for RUNWAY (item 1), ARBAR2 (item 2), and ADSR (item 12).

ISTRGY - The original operating strategy of the configuration being analyzed.

J - Typically, the trail aircraft in the current arrival pair IJ.

JBOMB - The maximum number of iterations to be performed by the f.e.d. mix logic.

K - Typically, the first departure in the IJ gap.

M - Medium-spaced parallel runways -- originally 3500-4299 feet apart, but currently 2500-4299 feet apart.

max - maximum.

min - minimum

MMC - Marginal Meteorological Conditions.

N - Near-spaced parallel runways (2500-3499 feet apart) -- not a separate operational category today.

NAME - On each header line in the input file, the arbitrary title for each data item.

NCARD - A flag which indicates the final data item for each capacity calculation (not necessarily the final data item in the input file).

NEWRUN - Item 0 of the input file, containing values of IMODEL, ISTRGY, and IALT.

OPENV - Line 10 of the input file, containing information needed for non-parallel, non-intersecting runway configurations.

OPENVX - The distance between the thresholds of two open-V runways.

OTHERS - Item 20 of the input file containing miscellaneous data.

P - Present ATC system, standard set of parameter values.

PFED(I,J) - The probability that departure K is the first enqueued departure after arrival I.

PHR(K) - The proportion of type K in the overall fleet mix.

POTG - The percentage of touch-and-go operations.

PV - The probability of violation for all stochastic variables in the program (arrival R.O.T., etc.) except interarrival time.

PVI - The probability of violation for the interarrival separation. The average separation is such that only this proportion of all separations is less than the minimum separation, DLTAIJ.

Q-logic - The program logic by which the possible effects of previous departures are accounted for.

RJE - Remote Job Entry -- batch processing of computer programs, using card decks.

R.O.T. - Runway Occupancy Time

RUNWAY - Item 1 of the input data file, containing aircraft fleet mix information.

SIGAI - The standard deviation of the time for an arrival to clear the runway intersection.

SIGDI - The standard deviation of the time for a departure to clear the runway intersection.

SIGMAA - The standard deviation of the interarrival time.

SIGMAC - The standard deviation of the time from departure clearance to start of roll.

SIGMAR - The standard deviation of the arrival runway occupancy time.

SIGMAS - Item 19 of the input file, containing standard deviation data.

SIGMDR - The standard deviation of departure runway occupancy time.

SIGTGR - The standard deviation of touch-and-go runway occupancy times.

T & G - Touch-and-go -- landing aircraft takes off again immediately, without stopping.

TAA - The weighted average interarrival time for all aircraft pairs.

$\overline{\text{TAA}}(I,J)$ - The average interarrival between arrivals I and J.

TD - Item 7 of the input file, containing minimum departure-departure separations.

TDD - The weighted average interdeparture time for all aircraft pairs.

$\overline{\text{TDD}}(K,L)$ - The average interdeparture time between departures K and L.

TGRBAR - Item 9 of the input file, containing touch-and-go occupancy times.

TGRBAR(I) - The average touch-and-go occupancy time for class I arrivals.

THETA - The angle between non-parallel runways.

THDISP - For alternating arrivals, the relative displacement between runway thresholds.

TWOIN - Item 11 of the input file, containing information for certain intersecting runway configurations.

TXI(I,K) - The time from release to clearing the intersection for departure I on runway K.

V(I) - The final approach velocity of arrival I.

VFR - Visual Flight Rules.

VIS - Weather visibility, statute miles.

VMC - Visual Meteorological Conditions.

7777 - Special value for arrival percentage (IPA), which causes the program to calculate and print the capacity for arrival priority, for the maximum number of intermediate points, and for departure priority.

8888 - Special value for arrival percentage (IPA), which causes the program to calculate and print the capacity for arrival priority and for departure priority.

9999 - Special value for arrival percentage (IPA), which causes the program to calculate and print the capacity for arrival priority only.

APPENDIX D

REFERENCES

1. C. T. Ball, "Model Users' Manual for Airfield Capacity and Delay Models -- Book I," Federal Aviation Administration, FAA-RD-76-128, November 1976.

2. Federal Aviation Administration, "Air Traffic Control," Handbook 7110.65B, 1 January 1980.

3. A. L. Haines, "Parameters of Future ATC Systems Relating to Airport Capacity/Delay," The MITRE Corporation, MTR-7766, Rev. 1 (FAA-EM-78-8A), June 1978.